Chapter 3
Communications, Sensors, Maintaining Interest in Missile Defense, and the Strategic Defense Initiative, 1970-1989

The Slow Revival of Interest in Space

Although handicapped by the policy changes of the late 1950s and early 1960s that centralized control of space, intelligence and communications programs, and wracked by the consequences of the Vietnam War, the Army maintained an interest in space and increased its stake in ballistic missile defense. Since the Army was the service most advanced in the use of space at the time, it lost the most during the reallocation of roles and missions. These institutional changes affected the ways the Army exploited space. One of the most dramatic changes occurred in 1961, when Secretary of Defense Robert S. McNamara's DoD Directive 5160.32 Development of Space Systems removed the Army from the business of launching satellites and conducting DoD satellite reconnaissance efforts. While the directive centralized control, supervision and coordination of satellite development and operations, it allowed the Army to continue its work on communications satellites and ground stations. Through the 1980s, the Army used space to provide theater commanders with long-haul communications systems.

Change in the Army's interest in space began when Secretary of Defense Melvin H. Laird modified McNamara's management and decision-making practices. The Nixon Administration appointed a Blue Ribbon Defense Panel that made more than 100 recommendations about the department's organization and functions in a 1970 report. A number of the proposals were implemented while Laird was Defense Secretary. He did not completely end McNamara's system, but described his policy as "participatory management." While retaining policymaking decision authority for himself and his deputy secretary, the Joint Chiefs of Staff and the Services became responsible for detailed force planning, while the individual military departments gained more responsibility for managing their own development and procurement programs. The policy gained the senior military leadership's cooperation in reducing the defense budget and the size of the military establishment. The Army saw immediate advantage to this new system when the secretary revised DoD Directive 5160.32 in September 1970, changing the division of DoD satellite development responsibilities three ways. First, each service conducted research and received approval to develop "unique battlefield and ocean surveillance, communication, navigation, meteorological mapping, charting and geodesy satellites." The Air Force still performed research and development and produced systems for launch support, launch vehicles, warning and surveillance satellites to detect enemy nuclear capabilities, and orbital support operations. Finally, the DoD Director of Research and Development became the focal point for space technology and systems to prevent duplication, minimize technical risk and cost, and ensure multiple service needs were met. This new policy allowed the Army to slowly return to space.

SAFEGUARD-The Next Generation: Hardsite Defense

In the post-Vietnam period, the Army experienced a renewed emphasis on professionalism and modernization. As part of this renewal, the Army continued to concentrate on ballistic missile defense. Beginning in 1969, as the Army pursued deployment of the SAFEGUARD System, the SAFEGUARD Systems Command (SAFSCOM) received orders from the Deputy Secretary of Defense to address the next generation of BMD development. In February 1971, SAFSCOM established the Hardsite Defense (HSD) Project Office, a prototype demonstration program.[1] As described by Secretary of Defense James Schlesinger, Site Defense "would give us the option to defend our Minuteman force against a Soviet ballistic missile attack … or in the event that an acceptable … limitation of strategic offensive arms cannot be achieved … it would give us the option to deploy a more advanced ABM system."[2]

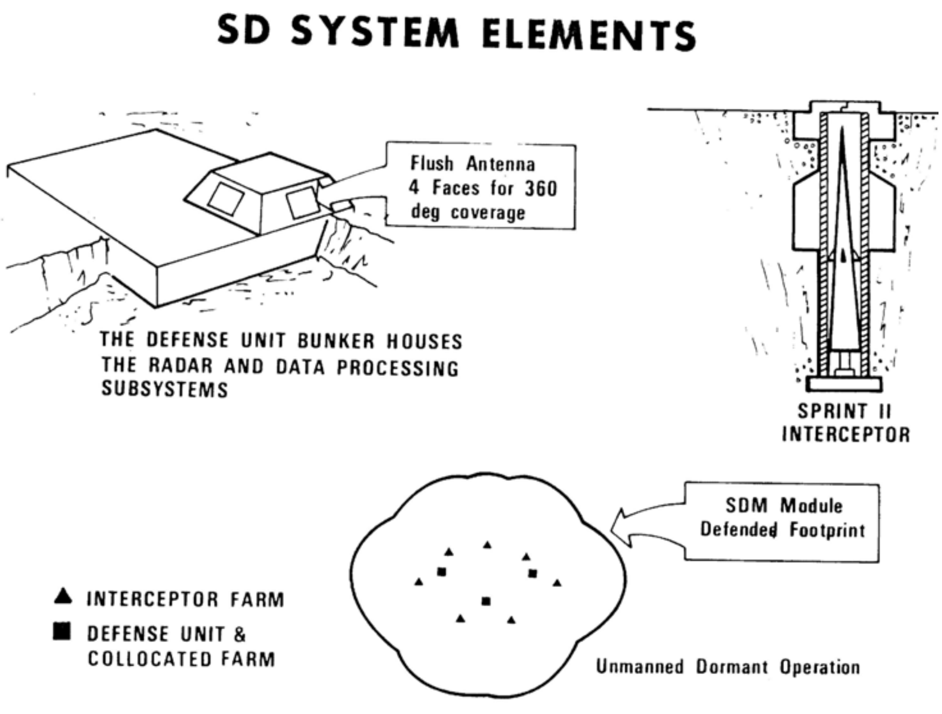


Fig. 3-1. The artist's drawing illustrates the system elements of the Site Defense concept and its proposed deployment within the defense unit.

Under the revised charter, the SAFEGUARD System Manager had two distinct missions, to "develop and assure timely, effective deployment of the SAFEGUARD Ballistic Missile Defense system and [to] plan and carry out a Hardsite prototype demonstration program."[3] The program included a deployment option, but no decisions were taken at this point. The resulting concept called for phased array radar, an interceptor, and commercial data processing equipment to be deployed in groups to protect MINUTEMAN sites and each other.[4] The new radar, smaller and built to a greater degree of nuclear hardening, would be more resistant to nuclear effects. The new interceptor, the SPRINT II boasted greater accuracy and maneuverability and improved silo hardening. With these innovations, the HSD-augmented SAFEGUARD would be capable of handling a larger, more sophisticated threat than SAFEGUARD. In February 1972, the Secretary of the Army announced the award of the Site Defense Prototype Demonstration Contract.[5] A demonstration program for the prototype was planned for Kwajalein in 1976.

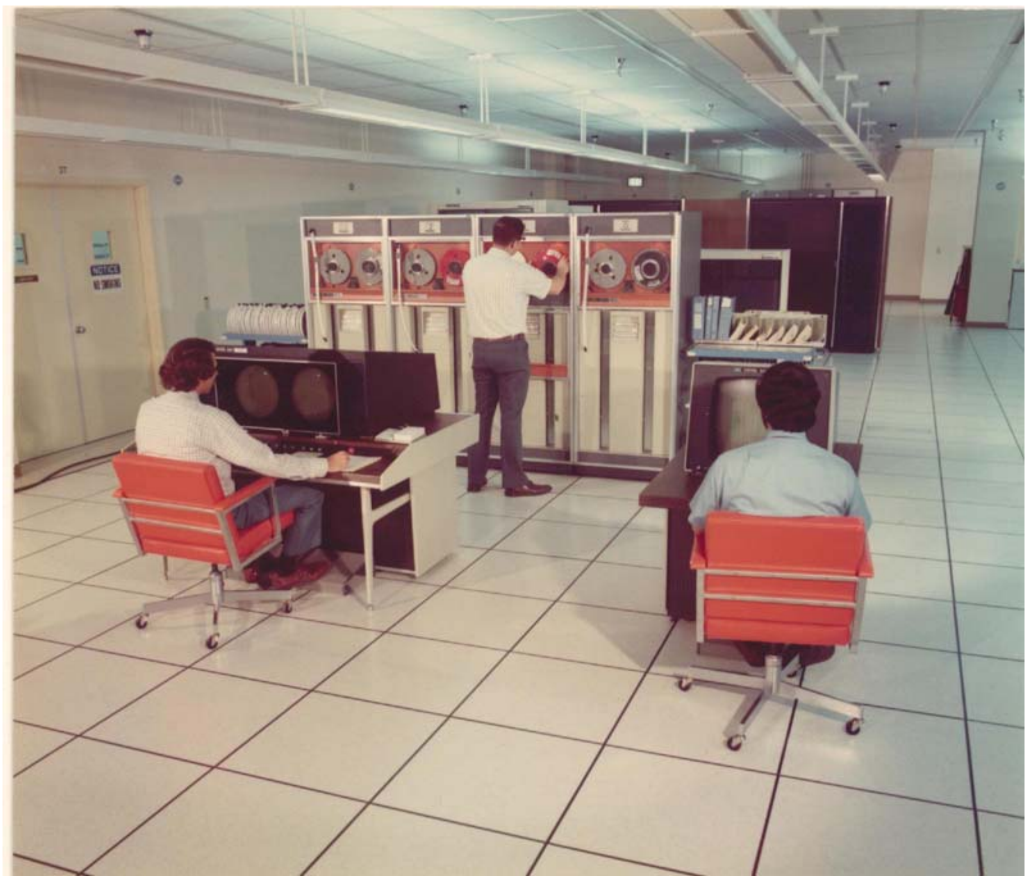


Fig. 3-2. Computer systems play vital roles in missile defense. One such system for Site Defense was this CDC-76-computer, which was operated and maintained by the control consoles in the foreground-May 1974.

Everything changed in 1974, when a congressional ban on prototyping limited site defense to research and development at the subsystem and component levels. As the Site Defense System Fact Book explained, the project office instituted a new two-phased approach – Validation and Integration.[6] The validation phase focused on upgrading key technical elements, e.g. bulk filtering, discrimination, software development, operation in a nuclear environment and dormancy. Integration ensured that the Site Defense design is "abreast of newly emerging offensive and defensive capabilities."[7] Previously planned missile intercepts for the SPRINT II were cancelled. With these changes, the Site Defense Project became the Systems Technology Program.[8]

The Ballistic Missile Defense Organization

That same year, the Secretary of the Army announced that all ballistic missile defense efforts would be realigned under one organization and, on 20 May 1974, the SAFEGUARD System Organization was redesignated the Ballistic Missile Defense Organization (BMDO).[9] The same General Order established the Ballistic Missile Defense Advanced Technology Center (BMDATC). The BMDATC, a field operating agency under the BMD Program Manager replaced the ABMDA.[10] Despite this reorganization, the BMD Program Manger remained principal assistant and staff advisor to the Office of the Chief of Staff of the Army. The mission for the new organization was comparable to that of SAFEGUARD. The Secretary of the Army tasked the BMDO: (1) to deploy and operate the SAFEGUARD System; (2) to execute the Site Defense program; (3) to conduct research and development in advanced BMD technology; and (4) to manage the Kwajalein Missile Range (KMR) as a National Range.

On 1 March 1975, the BMDATC received its own mission, to "formulate and execute approved BMD programs of exploratory and advanced development in BMD technology within the guidance and direction of the BMD Program Manager."[11] In addition, it would "(a) provide the advanced technology foundation for improving ballistic missile defense capability; (b) provide a measure of the BMD technology art to avoid technological surprise by an adversary; and (c) assist in the development and assessment of future U.S. strategic offensive systems." Specifically the BMDATC focused on five technology areas: discrimination, data processing. optics, radar, and interceptors.

With SAFEGUARD's inactivation, the BMDO experienced many changes. The BMD Program Manager recommended that the PM position transfer from Washington to Huntsville. The Washington-based element would be streamlined and many functions transferred to Huntsville and BMDSCOM. Emphasis was placed on the continued operation of the BMDSCOM and the BMDATC. The reorganization of BMDSCOM, conducted in conjunction with a reduction-in-force, was completed on 10 December 1976.[12]

Ballistic Missile Defense in the 1970s

The period between 1974 and 1983 began with declining interest in BMD initiatives as demonstrated by the decision to cancel the SAFEGUARD program and to redirect the Site Defense program. The decision was also made to move the Homing Overlay Experiment (HOE) into "high gear" and accelerate development of a defense for U.S. ICBMs.[13] Although no longer in the forefront of military proposals, the BMD effort was not totally abandoned. In 1976, Secretary of Defense Schlesinger testified to the Senate that "we must continue a BMD effort of significant breadth and depth to ensure that we can keep pace with the continuing Soviet BMD efforts and improvements." He added, "Our continued effort is essential not only as a hedge against a sudden abrogation of the ABM Treaty, but also because our demonstrable competence in this field will continue to motivate the Soviet Union to negotiate additional limits on strategic arms."[14]

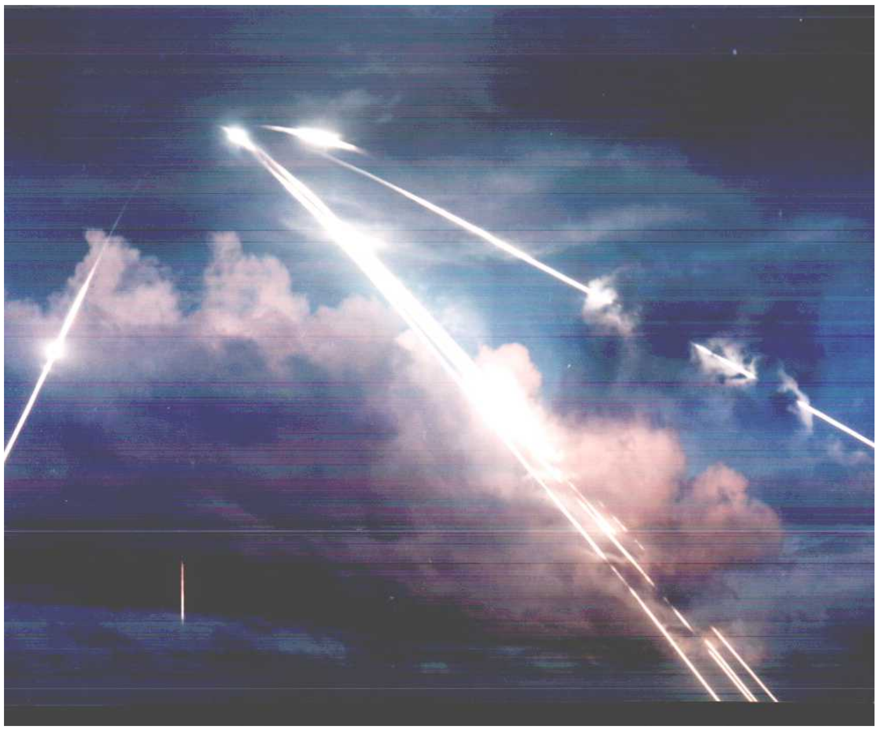


Fig. 3-3. Data collected during reentry measurement studies are important to a successful intercept. Reentry vehicles blaze through the skies over Kwajalein.

Two years later, amid growing concerns about Soviet missile capabilities, the Deputy Under Secretary of Defense Research & Engineering (Strategic and Space Systems) placed specific emphasis on "near-term defense concepts and technologies applicable to defense of our land-based missile forces in the 1980s." At the same time, Secretary of Defense Harold Brown, in his report to Congress, observed, "An aggressive BMD R&D program is vital to this nation's interest." Brown added that the technological base developed by the Systems Technology and Advanced Technology programs provided cost-effective alternatives for "maintaining survivability of our strategic retaliatory elements in the ICBM threat environment."[15]

The BMDO subsequently received orders to conduct a Minuteman Defense II study. While briefing the U.S. Congressional Budget Analysts, the BMD Program Manager explained, "The restrictions on deployment previously were thought to be such that a treaty-limited deployment would not be worthwhile. However, due to advancing technology, this is no longer true and a limited deployment can be useful." Meanwhile, BMDO summarized their program as an effort "to provide a hedge against the strategic uncertainties associated with the ballistic missile threat to the United States." They further explained that BMD research and development served "to keep the U.S. abreast of the potentialities of new component and system technologies to guard against Soviet technological surprise or a perception on their part of sufficient technological advantage to suggest the attractiveness of abrupt ABM Treaty abrogation."[16]

Although BMDO was limited by funding constraints and the Congressional ban on prototyping that remained in effect until 1981, it did achieve a number of breakthroughs in these years.[17] The two primary elements of the BMD program, the Advanced Technology Program (ATP) and the Systems Technology Program (STP), worked together to develop and evaluate innovative means to address BMD. As Major General Robert Creel, the BMD PM, explained, "From the ATP we want a futuristic, imaginative search for better ways to do the BMD job, while from the STP we require an objective evaluation of systems applications of emerging components and concepts."[18] In addition to traditional interceptors and sensors, BMDO scientists and engineers explored and validated new technologies to achieve its missions. Some of these instrumental initiatives are examined below.

Systems Technology Radar

Developed as part of the Site Defense Program, the Systems Technology Radar (STR) was a key element of the Systems Technology Test Facility (STTF) constructed on Meck Island in Kwajalein Atoll. Installation of the STTF began in May 1976 with data processing computers. The STR arrived on Kwajalein in September 1976. The full STTF achieved initial operation in November and full operating capability on 1 June 1977. Testing began immediately with planned Air Force ICBM tests.[19] The system demonstrated its tracking capability in June 1977. On 3 September 1977, the STTF successfully accomplished bulk filtering of low velocity tank fragments entering the search volume, and gathered discrimination data on reentry vehicles on 13 September.[20]

In 1978, officials reoriented the Systems Technology Program to emphasize the application of more mature technologies developed by the BMDATC. The STP discontinued system performance analysis of the terminal defense system to fund these new experiments/systems analyses. The exception was the STR program that demonstrated the STTF's ability to perform specific critical functions such as bulk filtering, track in reentry clutter and discrimination and those that established critical functions and performance levels for other system functions.[21] Verification testing, concluding in September, demonstrated that the lower-level and subsystem radar performance met and exceeded most baseline specifications. The STTF completed 50 tests of the Site Defense Radar and data processors in September 1980.

The STR, designed to provide data in terminal, low-altitude and midcourse operations, represented a major improvement over the SAFEGUARD Missile Site Radar.[22] The unmanned system was equipped with fully automatic electronic beam steering capable of transmitting thousands of beams per second. The STR also employed a "more versatile transmitted waveform in combinations with a more advanced signal processors [which permitted] better discrimination."[23] Given these advances, the STR could serve as a stand-alone radar system for defense of the Minuteman missiles. In addition, the radar was an important element in the underlay of the proposed layered defense concept of the late 1970s/early 1980s.

Designating Optical Tracker (DOT)

Recognizing the inherent limitations of ground-based radars, BMDO engineers explored the feasibility of airborne/spaceborne sensors to conduct target discrimination. One product of this investigation was the Designating Optical Tracker (DOT) program. The DOT, established in 1975, sought to determine the feasibility of a probe-launched long-wave infrared (LWIR) sensor to detect and track incoming ICBM warheads.

Fig. 3-4. The Designating Optical Tracker (DOT) enjoyed a perfect test record and demonstrated the viability of the onboard infrared optics technology. The DOT on its launch pad at the Kwajalein Missile Range.

Fig. 3-5. The DOT sensor package recovered from the Pacific to be prepared for the next test.

The DOT was an infrared telescope. The probe was launched by a Castor I rocket above the atmosphere in a series of tests conducted at Roi-Namur in the Kwajalein Atoll. Following each test, the telescope parachuted into the ocean to be recovered, refurbished and reused. In five consecutive tests between 1978 and 1982, the DOT demonstrated that a LWIR sensor could discriminate, designate, and track a reentry vehicle. The tests also collected signature data on targets and debris and provided research data on the impact of radar, celestial backgrounds, targets, optical chaff penetration aids, and atmospheric conditions on LWIR sensors.[24] The DOT set the standard for future LWIR technology.

Airborne Optical Sensors

As discrimination had always been a concern for researchers, the BMDO conducted several data collection and sensors projects in the 1970s and early 1980s. Concurrent with the DOT, researchers theorized that airborne sensors could provide an expanded tracking and discrimination capability. The Optical Aircraft Measurements Program (OAMP) was the first such experiment. Comparable in size to a compact car, the OAMP sensor was mounted into a modified Boeing 707 aircraft. The sensor recorded data in three infrared bands, with the first telescope equipped with simultaneous spectral and radiometric measurement capabilities. During the two-year period of 1982-3, the OAMP collected signature data on Soviet reentry vehicles and missile launches.[25]

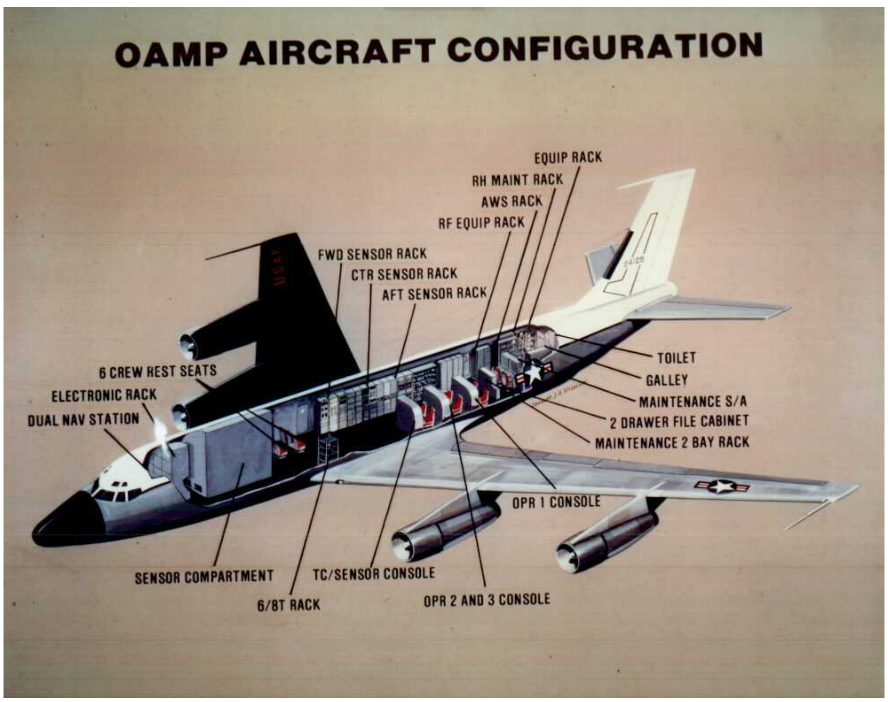


Fig. 3-6. The Optical Aircraft Measurements Program was an airborne sensor installed into a U.S. Air Force aircraft.

Building upon the DOT and OAMP programs, the Systems Technology Program received permission in October 1983 from Mr. James Ambrose, Under Secretary of the Army, to proceed with a new initiative: the Airborne Optical Adjunct (AOA). The BMDO created the AOA "to experimentally investigate the technical feasibility of using airborne optical sensors for detecting, tracking and discriminating ballistic missile reentry vehicles and handing over trajectory data to ground-based radars."[26]

To address the potential threat, the AOA program called for two OAMP sensors and a data processing unit to be installed in a C-135B aircraft. Funding restrictions later reduced the program to one sensor aboard a modified to an experimental Boeing 767.[27] Nevertheless, the Army awarded an initial five-year contract to Boeing Aerospace in July 1984. Subsequently renamed the Airborne Surveillance Testbed (AST), the optical sensor was the first BMD project to be incorporated into the next generation ABM initiative and it continues to play an important role in missile test programs and exercises.

Advanced Research Center

Beginning in the early 1970s, the Advanced Research Center (ARC) provided the BMD community with an integrated and centralized data processing capability specially designed to meet the software and hardware needs of ballistic missile defense. In FY75, the ARC had four missions:[28] developing methodologies for designing and implementing the massive real-time BMD software; testing large, advanced data-processing systems for applicability to BMD; testing validating and demonstrating software processes for specific BMD applications (simulations); and conducting systems analysis studies for new technical requirements. In many respects the mission remains unchanged as the ARC continues to provide a cost effective focal point for BMD data processing research and simulation.

Fig. 3-7. The Advanced Research Center's simulations capabilities have applications to all of the services. Soldiers from this command practice battle management techniques.

Work conducted at the ARC made great advances in data processing technology. Normal computer performance in the mid-1970s, for example, was measured at 20-30 millions of instructions per second (MIPS), an improvement over the SAFEGUARD systems.[29] During the mid-1970s, however, the ARC was testing the parallel element processing ensemble (PEPE) with an operation rate of 800 MIPS. Engineers designed the PEPE "to handle high correlation and high computation loads, as well as a high file-search load" to meet BMD requirements to include tracking and discrimination of warheads and decoys, controlling radar beams, etc. Other concepts under review during this time period included distributed data processing, micro-processing and missile borne data processors.

Directed Energy Research

Along with the various forms of radars and sensors, the Army was also experimenting with lasers. The concept of directed energy weapons has existed since ancient times.[30] By definition a directed energy weapon "generates radiant energy or energetic particles, focuses them into narrow beams and points and delivers them to targets." The source of this energy can be chemical fuel, electrical power, intense sources of heat, or high explosives. Meanwhile, "the beams consist of charged or neutral atomic particles or electromagnetic radiation and are capable of near-instantaneous delivery to targets."[31] During the 1970s, the Ballistic Missile Defense Advanced Technology Center explored two different directed energy technologies: neutral particle beams and high energy lasers.

The Advanced Research Projects Agency (ARPA) began initial research exploring military applications of directed energy weapons in the late 1950s. ARPA initiated the particle beam weapon program in 1958. The weapon would direct "a beam of atomic particles (electrons or protons) toward a target at or near the speed of light and could rapidly redirect its beam of particles among a multitude of targets." [32] Given the nature of the light beam, the Neutral Particle Beam (NPB) can penetrate clouds and is not adversely affected by poor weather conditions. In addition, the NPB can also penetrate the exterior body of the target and thus destroy the electronics and circuitry which control it.

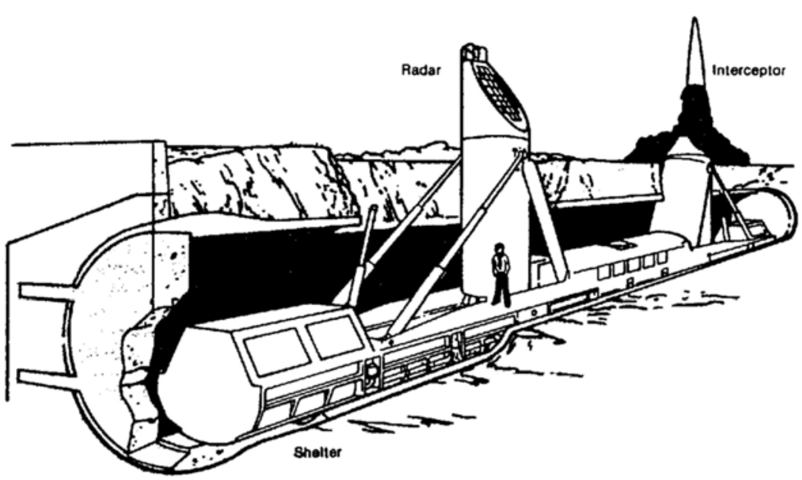
The Army/BMDATC was the principal developer of particle beam technology throughout the 1970s. The two primary efforts were the exoatmospheric NPB accelerator program and the collective ion accelerator experiment. In 1980, the Defense Science Board recommended that the NPB remain a technology program. It transferred to the Defense Advanced Research Projects Agency (DARPA) in 1981, when they became the manager of all NPB programs. The BMDO, however, continued to oversee contracts and monitor the DARPA-funded programs.

Research in laser technology began with ARPA in 1962 as studies addressed the effects of high energy lasers in BMD. In the 1970s, the BMDATC addressed several critical technology issues related to chemical and high energy laser weapons. Included among these issues were producing high-intensity, high-quality ion sources, neutralizing particles in a high energy charged beam, developing high energy laser beams for ballistic missile defense, and developing an adequate data base for target-beam interactions.[33] By the end of the decade, researchers had demonstrated that lasers could work in conjunction with pointing and tracking devices to form an effective weapons system.

In the FY76 Defense Authorization Bill, the Department of Defense recommended White Sands Missile Range as a suitable location for a high energy laser range testing. In October 1978, it was reported that "Congressional officials are pressing the Army to begin space-based laser weapons development."[34] In response, the Army began to change the program from endoatmospheric tactical laser weapons application to conceptual designs for space-based laser weapons. Then, in 1980, following policy established by President Jimmy Carter, Secretary of Defense Harold Brown directed the services to explore all potential uses of lasers but to emphasize the use of lasers in space.[35] For the BMD organization, the focus became the potential use of lasers to destroy ballistic missiles in the boost or midcourse phase of their flight, before the deployment of the reentry vehicles.[36]

Low Altitude Defense (LoAD)/SENTRY

In the 1970s, as improved Soviet technology increasingly threatened existing intercontinental ballistic missiles, the Air Force developed a new ICBM, the MX or Peacekeeper missile. To improve its survivability, the Air Force explored a number of basing options, including mobile systems. It was the Army's role, in particular the BMD organization, to develop a suitable ABM system to protect the ICBMs. The response was the Low Altitude Defense (LoAD) system. In 1977, the BMDSCOM chartered a six month study entitled "Mobile ICBM Defense Concept Analysis" to review deployment issues.[37] The study team determined the circumstances under which LoAD could improve the survivability of the MX, assessed the feasibility of silo-based ICBMs, examined candidate MX defense concepts, and identified actions required by BMD to achieve a mid-1980s deployment.



Artist's Concept of LoAD Unit for Defense of MX in Multiple Protective Shelters

Fig. 3-8. Designed to protect the Air Force's MX missiles, the LoAD/SENTRY was to be a mobile defensive interceptor.

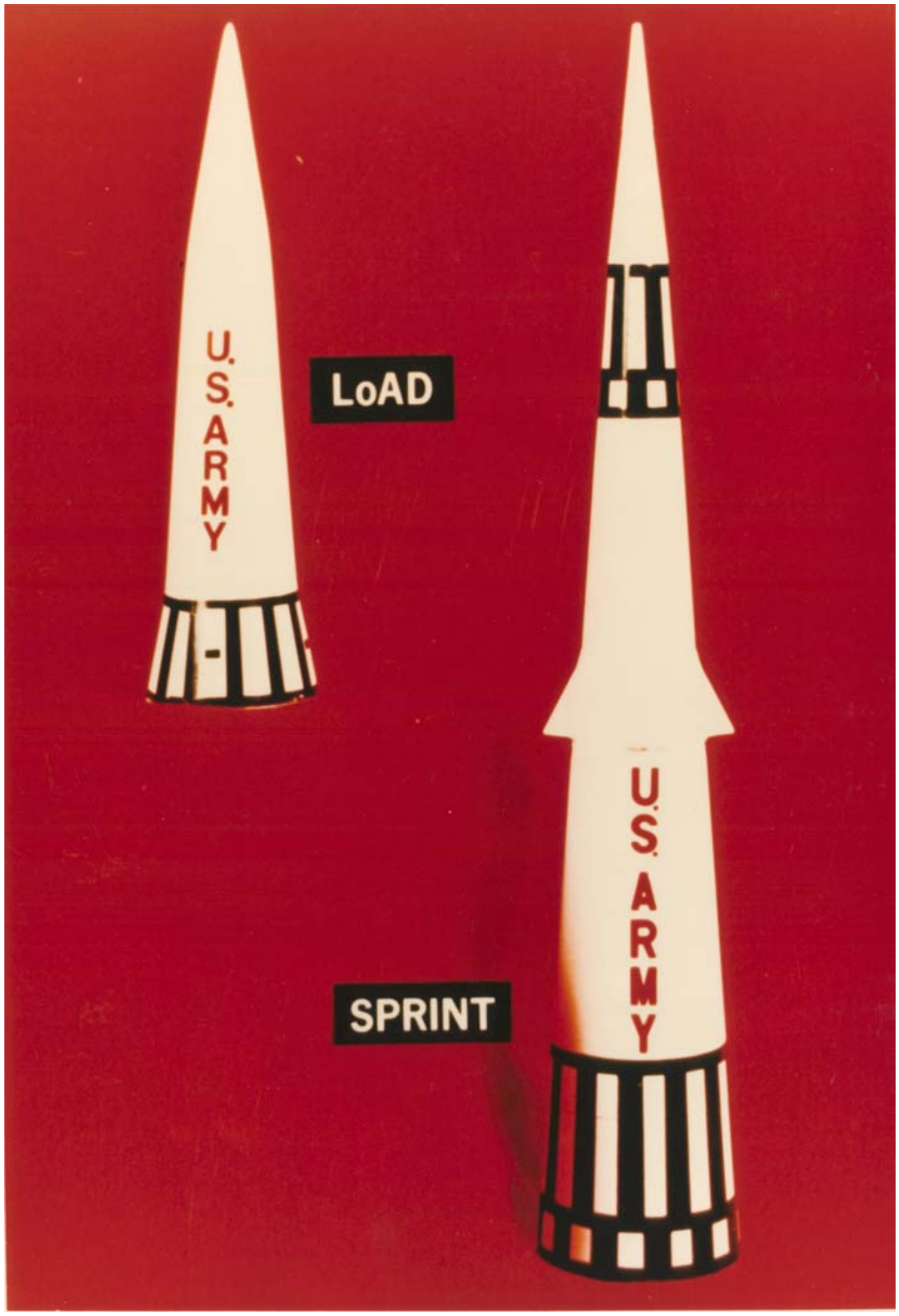


Fig. 3-9. This drawing illustrates the differences between the SPRINT, developed in the 1960s, and the smaller LoAD, a product of the 1970s.

At the same time, the Ballistic Missile Defense Organization began to review a new layered defense system described as being divided into an overlay and an underlay. The overlay focused on exoatmospheric interceptions employing a non-nuclear interceptor equipped with a number of small kill vehicles. This program was still in the early stages of development. The underlay, however, was an improved Site Defense system that engaged targets in the endoatmosphere that had escaped the initial defense layer.[38] While the overlay interceptor was not yet fully defined, the LoAD system was identified as a suitable underlay.

On 22 January 1977, the BMDSCOM chartered the Low Altitude Defense (LoAD) system. It was designed to operate at altitudes under 50,000 feet. The system would incorporate a series of radars, distributed data processors and nuclear-tipped interceptors.[39] Its size and design would complement any of the proposed deployments for the MX ICBM. In 1979, the Carter Administration selected a mobile basing mode for MX. The design called for 200 Peacekeeper missiles to be stationed in 4600 hardened shelters.[40] Periodically the ICBMs and decoys would be moved among the various shelters in the cluster. Similarly the LoAD battery, consisting of three missiles and a radar system, would be moved among the shelters in an underground system.

Congress lifted the prototyping ban in 1981. The new administration, however, did not concur with the mobile basing system. In 1982, Secretary of Defense Caspar Weinberger issued a BMD Program Directive to support all MX basing options, with particular concentration on a closely based system.[41] The directive also called for the development of a non-nuclear endoatmospheric weapon. Based on this guidance, the BMDO planned to convert the LoAD to a non-nuclear interceptor and renamed the program SENTRY.

The next year, the BMDSCOM terminated the SENTRY program. One factor was the ABM Treaty that would have placed restrictions on a LoAD battery and prohibited deployment of a mobile system.[42] In addition, funding constraints coupled with the decision to deploy the Peacekeeper in existing silos contributed to this decision.

Homing Overlay Experiment (HOE)

With the advances made in infrared sensors and computer technology, the Army was ready to address kinetic energy intercepts. The first such effort was the Homing Overlay Experiment (HOE) Task Force, charted by the Systems Technology Program in March 1977. There was a great deal of interest in this endeavor; one of the proposed elements to the overlay of the layered defense system was the HOE.

The two-phased HOE effort began with technology verification, followed by the flight demonstration program scheduled for 1982-1983. The BMD engineers designed the experiment to resolve specific development issues. These were Search, Acquisition, and Detection; Discrimination (including scan to scan correlation); Designation; Homing Guidance Accuracy; D^3 and Track in the Natural and Induced Environments; and, Sensor to Sensor Handover/Correlation).[43] The overall objective was to demonstrate the exoatmospheric intercept of a mock ICBM reentry vehicle using infrared homing sensors and non-nuclear kill vehicle and thereby reduce the lead-time required to deploy an exoatmospheric non-nuclear interceptor.[44]

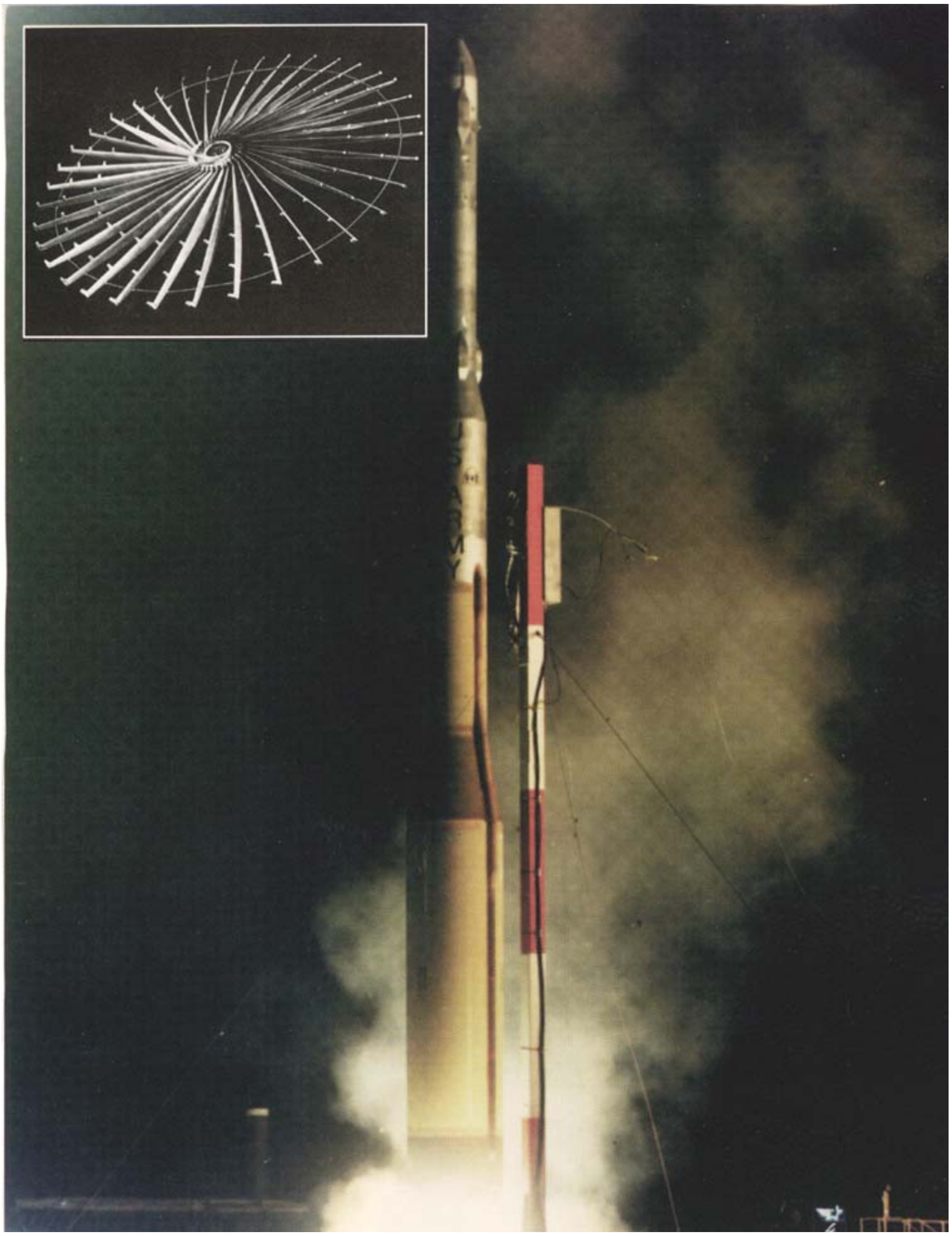


Fig. 3-10. Noted for its distinctive web (insert) designed to capture an RV, the Homing Overlay Experiment achieved the first kinetic energy intercept colliding with its target at a speed of 20,000 mph.

Launched by two Minuteman motor stages, the HOE kill vehicle consisted of a computer, a long wavelength infrared optical sensor package for guidance, and a unique kill device.[45] When the missile reached a point above the atmosphere, a sensor and computer on-board the MINUTEMAN launch rocket would locate and track the reentry vehicle.[46] The computer would then relay tracking data to the intercept vehicle. As the target neared, the kill vehicle would be launched and using its own infrared sensors and computer would home in on the target. In the final stage before intercept, the kill vehicle would unfurl the spokes of a 13-foot radial net that would capture the reentry vehicle.

On 10 June 1984, in its fourth and final flight test, the HOE successfully completed the first kinetic kill intercept.[47] Launched from Meck Island, the HOE kill vehicle intercepted a mock ICBM reentry vehicle over the Pacific Ocean at an altitude greater than 100 miles. In this test, "the HOE and the warhead closed at more than 15,000 feet per second, and telemetry data shows that they smashed into each other nose to nose."[48] As Principal Deputy Assistant Secretary of the Army Amoretto Hoeber explained, "We tried to hit a bullet with a bullet and it worked."[49] Ultimately, the evolution from nuclear to kinetic energy intercepts, represented by the HOE system, was "the first major revolution in ballistic missile defenses since the United States began BMD research in the 1940s."[50]

Flexible Lightweight Agile Guided Experiment (FLAGE)

The next non-nuclear kill technology achievement came in the same year when the Small Radar Homing Intercept Technology (SRHIT) completed its first flight test.[51] The SRHIT program sought to assess guidance and control technology to develop a missile capable of intercepting small high-velocity targets (tactical ballistic missiles) at low altitudes. Subsequently renamed the Flexible Lightweight Agile Experiment (FLAGE),[52] the program's mission was to demonstrate an accurate endoatmospheric interceptor, quantify the achievable miss distance in low atmosphere, and validate a 6-degree of freedom system simulation for endoatmospheric nonnuclear kill.[53]

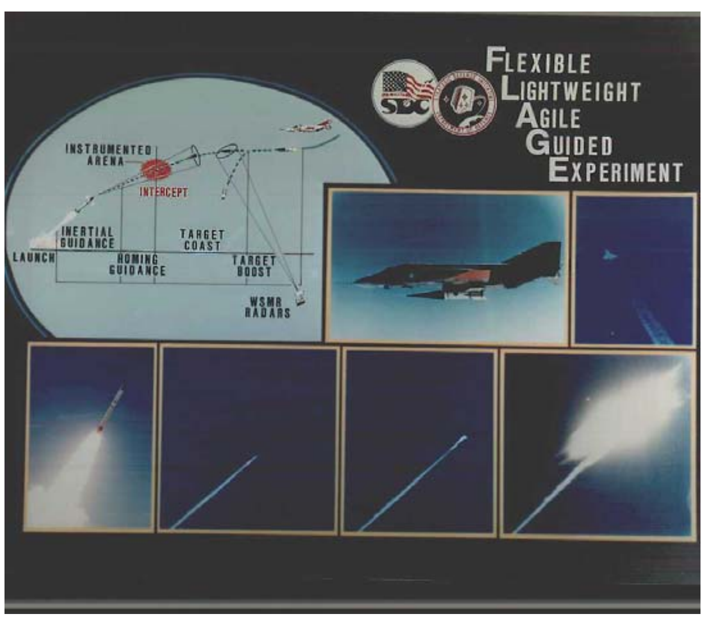


Fig. 3-11. This 27 June 1987 flight of the FLAGE shows the second successful intercept of the FLAGE program, a simulated RV launched from an aircraft.

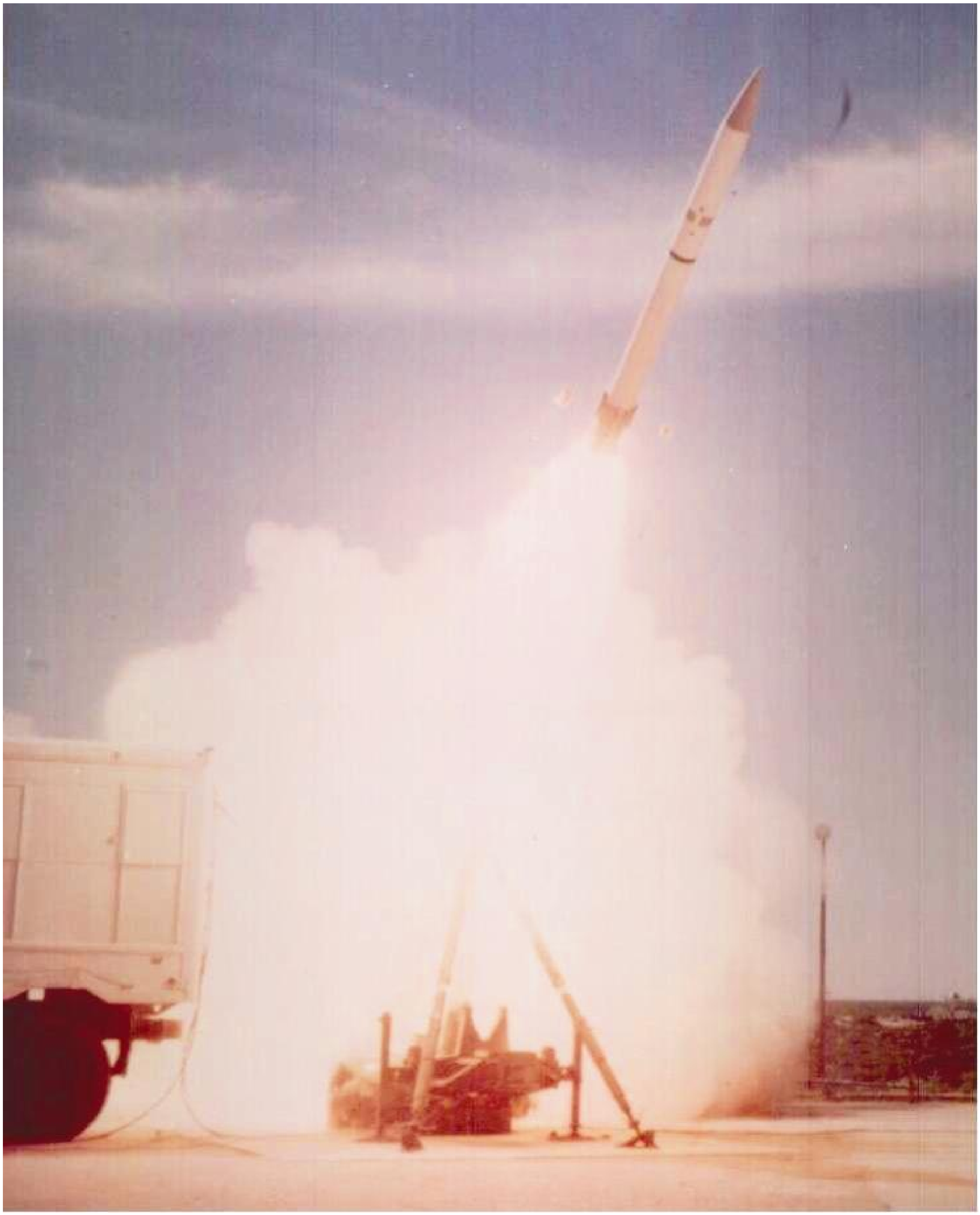


Fig. 3-12. Guided by 216 attitude control motors, the Flexible Lightweight Agile Guided Experiment demonstrated the feasibility of kinetic energy intercepts at short ranges.

During flight, the FLAGE's on-board millimeter wave radar would lock onto a target.[54] To maneuver the interceptor toward the target, 216 shotgun shell-sized shell motors, located in a band behind the radar, were fired selectively. Having demonstrated successful intercepts against a stationary sphere and an air-launched target in 1986 the FLAGE was tested against a Lance short-range surface-to-surface missile in the next test. On 21 May 1987, in its seventh and final test, the FLAGE demonstrated the feasibility of a short-range nonnuclear intercept, destroying the Lance at an altitude of 16,000 feet within seconds of launch.[55]

The Continuing Threat

At this time, the primary threat remained the Soviet Union. As of January 1981, authorities estimated the Soviet arsenal included 1400 operational ICBM launchers and 950 sea-launched ballistic missile launchers.[56] Officials believed that this arsenal would easily give the Soviets a 3 to 1 advantage over the American ICBM arsenal. The increasing numbers of ICBMs led DoD to approve a pre-prototype demonstration of the LoAD to develop technology to protect American systems. The 1970s also saw the proliferation of short-range missiles. The Soviet Union exported large numbers of SS-1 Scud B missiles to Warsaw Pact nations, China and North Korea.[57] These nations in turn supplied information and materials to such nations as Egypt, Iran, Libya and Syria.

In addition, as the decade progressed, there existed in some quarters a sense of "urgency because of assertions by certain intelligence officials and scientists that the Soviet Union may have a dangerously significant lead in the development of directed energy weapons."[58] Retired Air Force Major General George J. Keegan repeatedly warned that Soviet laser technology could be deployed as early as 1981. However, Dr. Ruth Davis, Deputy Under Secretary of Defense for Research and Advanced Technology, testified that in her opinion both nations were at similar stages with regard to directed energy technology.

The Scowcroft Commission

In January 1983, in response to Congressional opposition to the proposed MX basing plan, President Ronald Reagan established the President's Commission on Strategic Forces, chaired by Lieutenant General Brent Scowcroft (USAF, Retired). Known as the Scowcroft Commission, the group would review modernization efforts and find an acceptable basing mode for the Peacekeeper ICBM.

The Commission issued its report in April 1983. Following their review of the Peacekeeper deployment issue, the Commission favored basing the ICBMs in existing MINUTEMAN silos. This deployment plan contributed to the demise of the SENTRY program, which had become firmly associated with the mobile basing option.[59] With regard to modernization, the report placed greatest emphasis on command control and communications and battle management planning.[60] Other specific recommendations were (1) continued Trident submarine construction and development of the Trident II missile; (2) bomber and cruise missile defense programs; and, (3) vigorous research in anti-submarine warfare and Ballistic Missile Defense. The commission viewed the BMDATC as an innovator – an institution that could freely initiate and nurture innovation, an "organization that could support greatness." Although valued as a deterrent to the Soviets, they concluded, however, that "No ABM technologies appear to combine practicality, survivability, low cost, and technical effectiveness sufficiently to justify proceeding beyond the stage of technology development."[61]

The Army's Revival

Near the end of the decade, NASA fulfilled a 1969 promise made to the Chief of Staff of the Army to consider Army officers as astronauts when it identified future manned space missions. In January 1978, NASA announced it had selected 35 new astronaut candidates for the Space Shuttle program, the first group selected since 1969. Major Robert Stewart, the first Army astronaut, was a mission specialist among this group of candidates. While these changes gave the Army a potential opening, it had to wait to exploit them.

After the Vietnam War, the United States faced a revived Soviet threat. In the 1970s, the Soviets changed from Khrushchev's emphasis on conflict escalation to Brezhnev's desire to field a force not overly reliant on nuclear weapons. This reversion to traditional Soviet doctrinal themes – a combined arms approach to warfare – emphasized balanced force development.[62] The new Soviet force was upgraded and expanded through the 1960s and 1970s while American attention was focused on the Vietnam War and possible active Chinese hostility.[63]

In the early 1980s the strategic and tactical situations changed. In Washington, Ronald Reagan's election brought the critics of détente to power. Nevertheless, the United States continued to follow the same defensive strategy President Truman enunciated in the late 1940s aimed at containing Russian military expansion in Europe.[64]

The Soviets reverted to their earlier Cold War strategy in Europe, picking the times and places for action. The U.S.S.R. upgraded its forces and began to build a fleet to cruise the Mediterranean. However, the American nuclear deterrent was still potent and the Soviet forces were locked into a single theater of operations in Europe, unable to aid geographically noncontiguous allies or clients.

After the Soviet invasion of Afghanistan in 1979, the Carter Administration increased the defense budget. This accompanied a renaissance of doctrinal thought in the United States Army begun in 1975. Nevertheless, in the early 1980s many believed the West faced an economic and military crisis. An aggressive Soviet Union could undermine the West's ability to use its nuclear arsenal with nuclear, biological and chemical weapons. Economically, Soviet domination of space could mean Russian domination of the commercialization of space. These factors helped shift American strategic thought from deterrence to defense.[65]

The 1980s also saw a growing disquietude in Soviet journals of military thought as various authors analyzed AirLand Battle Doctrine. The cozy world of Soviet military planning was disturbed by the ways new types of technology were assimilated into military theory, doctrine and equipment. Beginning in the 1970s, Russian and American military theorists began writing about changes new information technologies made possible in warfare, asserting that future armies would be very mobile, linked by communications devices giving commanders a common picture of the battlefield. These armies would mount attacks throughout large theaters of operation, not a linear front. Battles would simultaneously expand in space and be shortened in time. While the Soviets did not have the economic or the technological strength to pursue these ideas, the United States began to experiment with them. As early as 1983, Soviet planners expressed doubts about their ability to handle future competition with the American military threat based on doctrine refined using the new information technologies.[66]

The Soviet military theorists' misgivings were echoed in the social situation that Mikhail Gorbachev inherited when he became General Secretary of the Communist Party of the U.S.S.R. in 1985. He confronted a stagnant society beset by unexpressed internal doubts and problems. Economic stagnation meant that the Soviet leadership was preoccupied with the old Stalinist concern of industrial modernization, a key target of the Gorbachev reforms. The effort to jump start a command economy reduced the growth in the military budget, cut conscription levels, slowed conventional weapons production, and shifted key personnel in the defense sector of the economy to the civil sector.[67]

The National Space Policy and the Army

Much of this became clear only in retrospect. President Reagan did come to office intending to strengthen the military. He believed that although overall Army modernization was overdue, it was crucial to update the nation's space systems. On 4 July 1982, he announced a new National Space Policy. It included commitments to (1) explore and use space for peaceful purposes by all nations; (2) participate in international cooperative space-related activities to achieve scientific, political, economic, or national security benefits for the United States; (3) pursue activities in space that support the United States' right of self-defense; (4) develop Space Transportation System capabilities and capacities to meet appropriate national needs and to make the system available to commercial and government users; and (5) continue to study space arms control options and consider verifiable and equitable arms control measures that would limit testing and deployment of specific weapons if compatible with American national security.

In 1988, the policy was updated, reaffirming the national commitment to space exploration and addressing civil, military and commercial space use. It established six goals, to (1) strengthen American security; (2) obtain scientific, technological and economic benefits for the general population and to improve the quality of life on earth through space related activities; (3) encourage private sector investment; (4) promote international cooperative activities while protecting American interests; (5) cooperate with other nations to maintain the freedom of space for all activities that increase the security and welfare of mankind; and (6) expand human presence and activity beyond earth orbit into the solar system. These goals would be guided by six principles: (1) a commitment to the peaceful exploration and use of outer space for all mankind's benefit, including national security goals; (2) pursuit of activities that support the right of self defense and the defense of allies; (3) rejecting any claim of sovereignty over outer space or celestial bodies; (4) considering national space systems to be national property; (5) encouraging the commercial use and exploitation of space technologies; and (6) conducting international cooperative space related activities to achieve national scientific, political, economic, or national security benefits.

These events and issues gave the Army an impetus to explore the ways it could use space and space-based military assets. However, the direct stimulus to re-evaluating the role of space assets as well as ballistic missile defense was the Army-wide debate over doctrine that took place between 1975 and 1982.[68] It was only then that the Army determined the ground commander's needs required the Army to return to space. As AirLand Battle doctrine developed, the entire conception of the battlefield expanded. The Army now concerned itself with the Deep Battle (a need to see and strike deep) and with the Rear Battle (its own needs for expanded command and control). Space-related activities offered the ground commander unique platforms for observation, positioning and communications over a greatly expanded area of concern: the operational level battlefield.

As it had with missile defense, the Army proceeded in an orderly, deliberate way that involved developing concepts and long-range planning followed by investment in programs. It was prodded by its growing needs for the products that existing and planned space systems would provide ground forces. Although intelligence and surveillance capabilities of satellites garnered the most attention, the Army also used space assets to multiply its abilities to deter, detour and defeat an enemy. The other services formed space commands to centralize and coordinate their efforts to use space. In 1982, the Air Force, as the lead armed service in space, established U.S. Air Force Space Command (AFSPC) "to further consolidate Air Force operational space activities." As a major command, AFSPC "supports Air Force space operations, including satellite control and Department of Defense space shuttle flight planning, readiness, and command and control." In 1983, the Navy, dependent on a world-wide communications and intelligence network for its surface and submarine fleet operations, formed Naval Space Command at Dahlgren, Virginia. It was not until 1984 that an Army Staff Field Element was activated at AFSPC headquarters. This marked the beginning of the U.S. Army Space Command.

President Reagan and the Strategic Defense Initiative

President Reagan's announcement of the Strategic Defense Initiative (SDI) in March 1983 reemphasized space's role in national defense and gave added impetus to the Army's ballistic missile defense effort.[69] Between 1983 and 1989, the Army began to pay attention to its space role in both a conceptual and organizational sense as it reinvigorated its ballistic missile defense effort.

Before the Scowcroft Commission submitted their report, the Joint Chiefs of Staff (JCS) had begun to assess the vulnerability of the American ICBM arsenal. Following a series of 40 meetings, between June 1982 and February 1983, the JCS concluded that a missile defense effort was required. In February, Admiral James Watkins, Chief of Naval Operations, presented a briefing to the JCS recommending that "the United States should quit looking for a complex basing mode for the MX missile, deploy a small number of MXs in MINUTEMAN silos, and start developing a strategic defense that would provide the basis for a shift 'to a long-term strategy based on strategic defense.'"[70] During an 11 February meeting with President Ronald Reagan, the JCS unanimously recommended that the United States pursue a national security strategy which placed increased emphasis on strategic defenses. As General John Vessey, Chairman of the Joint Chiefs, observed "Wouldn't it be better to defend the American people rather than avenge them?" Their recommendation marked the end of a 37-year policy of offensive deterrence.

A long time opponent of the doctrine of mutual assured destruction, President Ronald Reagan introduced a new era in BMD on 23 March 1983. In a televised speech to the nation, Reagan announced his concept for the Strategic Defense Initiative (SDI), popularly known as "Star Wars".[71] Following a review of Soviet capabilities, Reagan suggested that security should rest upon more than the threat of "instant U.S. retaliation to deter a Soviet attack." Recognizing that he established "a formidable, technical task", the President proposed that the nation pursue a missile defense policy and called on "the scientific community in our country… to give us the means of rendering these nuclear weapons impotent and obsolete." Reagan concluded, "We seek neither military superiority nor political advantage. Our only purpose - one all people share - is to search for ways to reduce the danger of nuclear war."[72]

In National Security Directive 85, "Eliminating the Threat From Ballistic Missiles," Reagan ordered "the development of an intensive effort to define a long term research and development program aimed at an ultimate goal of eliminating the threat posed by nuclear ballistic missiles."[73] In addition, a study would be conducted to assess the role the role of BMD in the future security strategy for both the United States and its allies. This study would also provide guidance for research and development, funding the fiscal year 1985 budget.

The Fletcher and Hoffman Reports

Presidential guidance resulted in two studies, both published in October 1983. The Future Security Strategy Study, or Hoffman Report, sought to determine the strategic and policy implications of the Strategic Defense Initiative. The second, the Defense Technologies, or Fletcher Report, would assess the state of missile defense technology and recommend a technology program for the new missile defense program.

The Hoffman report was composed of a series of papers by two study groups. Mr. Franklin Miller, Assistant Secretary of Defense for Strategic Forces Policy, headed an interagency body and Mr. Fred Hoffman, of the Pan Heuristics Corporation, led a group of contractors. Two of the major findings were "the idea that missile defense could enhance deterrence (Miller group) and the view that an anti-tactical ballistic missile system could serve as [a] useful first step toward a national missile defense system (Hoffman group)."[74]

The Fletcher Committee composed of a group of fifty scientists and engineers led by Dr. James Fletcher, former NASA administrator, outlined two models for the new missile defense research program. Their report, completed in February 1984, recommended a "blueprint" for SDI. The recommended research areas were Systems Concepts; Surveillance, Acquisition, and Tracking; Directed Energy Weapons; Conventional Weapons; Battle Management and Command, Control, and Communications; Survivability; Lethality and Threat Vulnerability; and Selected Support Systems. Proposed funding levels for this version totaled $1.405 billion in 1984, $2.385 billion in 1985, $3.43 billion in 1986, $4.284 billion in 1987, $4.623 billion in 1988, and $4.766 in 1989. The alternative, funded at a lower level, was known as the fiscally constrained program. It was this program that became the guide for the Strategic Defense Initiative.

The Strategic Defense Initiative and the Organization for Missile Defense

National Security Directive 119 authorized the SDI program to explore the possibility of developing missile defenses as an alternative means of deterring nuclear war and assigned responsibility to the Secretary of Defense.[75] The Secretary issued an interim charter to establish the Strategic Defense Initiative Organization (SDIO) on 24 April 1984 and appointed Air Force Lieutenant General James Abrahamson as the first director.[76] Department of Defense Directive 5141.5, dated 21 February 1986 established the SDIO as a multi-service agency of the Department of Defense. The director reported to the Secretary of Defense.[77]

The SDI management focused their initial efforts on three tasks: ensuring continuity of relevant programs, tailoring programs to fit the needs of the SDI, and initiating new programs to expand and accelerate the pre-SDI effort in BMD. Emphasis was placed on treaty compliance and non-nuclear technologies. The overall goal, however, was to provide the technical knowledge necessary to support an informed decision, about the "feasibility of eliminating the threat posed by nuclear ballistic missiles of all ranges, and of increasing the contribution of defensive systems to U.S. and allied security." This decision was to be made in the early 1990s.

The SDIO was a multi-service organization. The Army's years of ABM experience, however, proved to be the foundation, as the Army repeatedly took the lead in project development. This experience, according to one report, allowed the SDIO to protect the technology base, increase the emphasis on proof-of-feasibility experiments with increased investment in high risk, high payoff approaches, and continue examining multi-layered defense.[78]

The U. S. Army Strategic Defense Command

Fig. 3-13. "They Shall Not Pass" - is the motto on the distinctive unit insignia created in 1987 for the USASDC. The illustration symbolizes the defensive shield protecting the world from an incoming threat.

As part of the Strategic Defense Initiative, the Army was responsible for directing and managing research associated with Surveillance, Acquisition, Tracking and Kill Assessment; Directed Energy and Kinetic Energy weapons technologies; and Survivability, Lethality, and Key Technologies. To facilitate development of this new proposal, the Army sought to align its effort with the SDIO structure. In July 1984, the BMDO became a part of the Strategic Defense Initiative Organization.[79] One year later, effective 1 July 1985, the BMDO became the U.S. Army Strategic Defense Command, a field operating agency of the Office of the Chief of Staff.[80] At this point the BMDATC and the BMDSCOM continued to exist as separate entities.

These two organizations dissolved into the framework of the U.S. Army Strategic Defense Command (USASDC) on 6 January 1986. To correspond to the series of program elements established by SDIO, they were replaced by a series of five Directorates (Weapons, Sensors, Systems Analysis/Battle Management, Survivability, Lethality and Key Technologies, and Advanced Technology) and five Project Offices (Airborne Optical Adjunct, Terminal Imaging Radar, High Endoatmospheric Defense Interceptor, Exoatmospheric Reentry-vehicle Interceptor Subsystem, and Ground-Based Laser).[81] Each of these was devoted to the development of a specific weapon system or radar. During this period, project offices were created and disestablished as directed by the budget and focus of the SDIO.

In October 1988, President George Bush recognized the significant role played by the USASDC. Under National Security Directive 219, Lieutenant General Robert Hammond, USASDC Commander, was named the Program Executive Officer for Strategic Defense. With this position, LTG Hammond reported directly to the Army Acquisition Executive.

Star Wars

From the beginning, opponents criticized the SDI concept as an unrealistic proposal, more akin to the movie “Star Wars” than actual, achievable capabilities. Both politicians and scientists argued that the Reagan administration was “ambiguous” in their goals[82] and relied heavily on “exotic” technologies.[83] Even as the program became better defined, critics questioned the feasibility of the SDI program. At the same time, they argued that it would lead to another arms race and the militarization of space.[84] These arguments would appear frequently during the history of the SDI program impacting budgets and systems development.

The SDI Concept for a Layered Defense

Researchers from the SDIO, the Army and the Air Force proceeded to apply the SDI concepts and created a tiered, or layered, defense against enemy missile systems.[85] This layered defense would facilitate the intercept of an incoming missile during the three phases of flight: boost, midcourse, and terminal. Each of the services was assigned elements designed to track or intercept during specific phases of the missile flight. The USASDC and the Army assumed the lead in the SDI effort.

The Three Phases of ICBM Flight

Boost Phase – The three to five minute period from the ignition of the enemy missile's propulsion rocket to burnout, propelling the missile payload through the atmosphere into space to the desired trajectory. The missiles exhaust plume enhances detection, but speeds of up to 15,000 mph make an intercept challenging. In the post-boost phase, the nose cone separates from the booster rockets and releases the reentry vehicle(s) (RVs) and penetration aids (PENAIDS) (decoys and chaff).

Midcourse Phase – This is the longest period lasting 20-25 minutes for ICBMs, less for SLBMs. During this phase, the RVs and PENAIDS are traveling in an arc toward their targets. In the weightlessness of space, PENAIDS travel at the same trajectory and speed as the heavier RVs.

Terminal Phase – The RV and decoys reenter the Earth's atmosphere. Friction and heat caused by reentry help to distinguish between the targets. Nevertheless there is only a short time-30 seconds or so-to react and intercept the RV.

The SDI defense concept for the boost phase incorporated the Boost Surveillance and Tracking System, the Space-Based Laser (SBL), and the Ground-Based Laser (GBL). The USASDC shared responsibility for the SBL with the Air Force, while it was assigned sole control over the GBL. In the midcourse phase, the SDI system architecture envisioned a Space-Based Surveillance and Tracking System (SSTS), a Space-Based Interceptor (SBI), a Neutral Particle Beam (NPB), and the Exoatmospheric Reentry-vehicle Interceptor Subsystem (ERIS). The Air Force directed the development of the SSTS and the SBI and shared responsibility with the Army, USASDC, for the NPB. The Army then directed the evolution of the ERIS. The final layer of defense, the terminal phase, employed the Airborne Optical Adjunct (AOA), the Ground-Based Radar (GBR), the Ground-Based Surveillance and Tracking System (GSTS), and the High Endoatmospheric Defense Interceptor (HEDI). The USASDC had the lead on all of these programs. All three primary elements, the Air Force, the Army and SDIO, shared in the development of the Battle Management/Command, Control and Communications systems (BM/C^3).

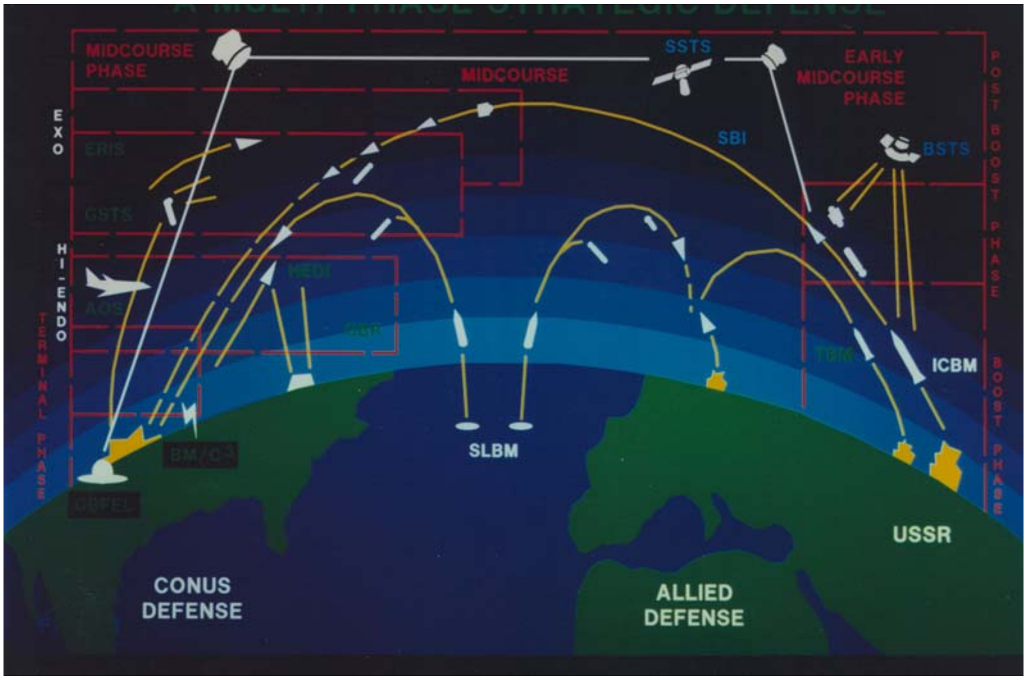


Fig. 3-14. The SDIO program called for a Multi-phase Strategic Defense. The layered architecture addressed the boost, mid-course and terminal phases of the target missile's flight.

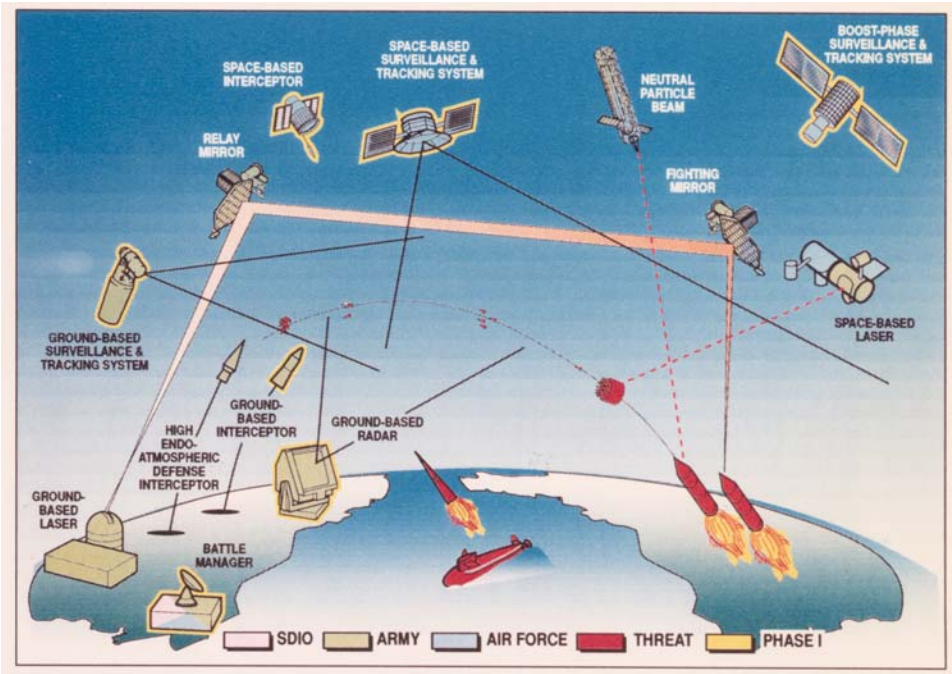


Fig. 3-15. This diagram of the Strategic Defense Initiative System Architecture Concepts attributes projects to the appropriate service or organization.

SDI-The Boost Phase

The Ground-Based Laser (GBL)

On 2 April 1984, the SDIO authorized the laser imaging technology program.[86] Two years later, on 26 March 1986, the USASDC created the GBL Project Office. Located at WSMR, New Mexico, the office oversaw the development of the ground-based free electron laser (FEL) technology integration experiment.[87] The goal was to develop a system that could intercept a target in the boost phase by bouncing the laser beam off relay mirrors based in space.[88] To this end, they explored the benefits of the radio frequency FEL and the more powerful induction FEL.[89] Initial tests showed that both approaches were feasible for full-scale development.[90] The Project Office subsequently elected to proceed with a dual laser concept. As the project continued to progress, the SDIO and USASDC began to explore the possibility of using the laser as an anti-satellite (ASAT) system.

Fig. 3-16. On 29April 1986, the ALTAIR radar on Kwajalein tracked its 100,000th deep-space satellite. In that same year, on 16 October, President Reagan signed Public Law 99-239, the Compact of Free Association between the United States and the Republic of the Marshall Islands.

Program redirections by SDI and repeated budget cuts, beginning in fiscal year 1988, however, forced frequent modifications and downscaling in the project. These events culminated in the eventual demise of the project in January 1991, six month after the official dedication ceremony for the new Ground-Based FEL facility.[91]

With the agreement of the SDIO, the Average Power Laser Experiment, a restructured version of the GBFEL, was transferred to the Directed Energy Weapons (DEW) Directorate. Research continued on laser programs under the auspices of the High Energy Laser Technology Division. In conjunction with this effort, the division also worked to evaluate the component design option of the FEL to use in a possible space-based FEL.

Fig. 3-17. A special facility for the Ground-Based Laser project was constructed at the White Sands Missile Range.

The Neutral Particle Beam (NPB)

In addition to this laser research, the DEW Directorate was involved in the development of the neutral particle beam technology. As defined by the SDI architecture, the NPB would be a space-based system with a variety of capabilities. An NPB would be used to penetrate the target to destroy electronics, ignite the explosives and highlight the target to aid identification. Given these anticipated capabilities the command also explored the effectiveness of the NPB as an ASAT system.

The NPB system itself is composed of a particle accelerator, beam focusing and pointing magnets, and a stripping device, to rid the beam of extra electrons. An NPB is created by accelerating negatively charged hydrogen or deuterium irons until they travel in a continuous wave or pulsed beam.[92] The resulting beam travels at a rate near the speed of light. Unlike a laser beam, the NPB does not interact with the magnetic fields in the atmosphere and thus travels in an unbendable beam. At the same time, however, an NPB is a line-of-sight system and cannot be retargeted with relay mirrors.

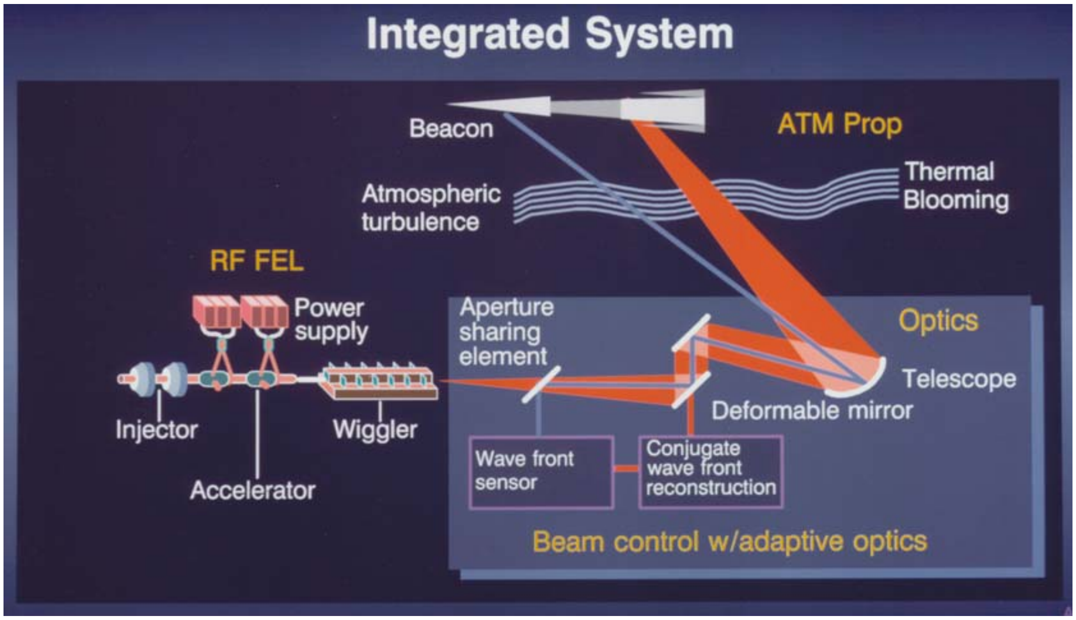
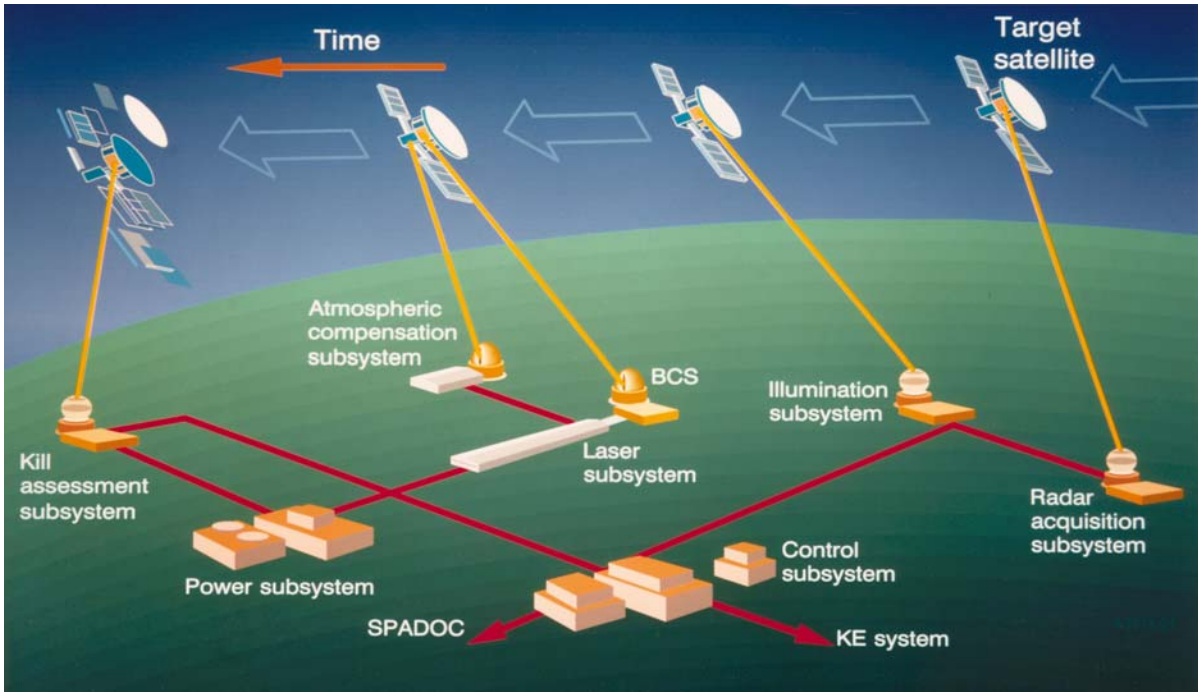


Fig. 3-18 and 3-19. These artists' concepts illustrate the proposed missions of the Ground-Based Laser. The first shows the Integrated System of the ground-based free electron laser. The second illustrates the system components for a theoretical ground- based laser anti-satellite system.



The Army was the principal developer of the NPB from 1974. As early as 1987, particle beam technology was described as the "closest to the required level of brightness of all directed energy options."[93] By 1992, the program had completed four of the eight objectives outlined in the 1984 directed energy plan. Specifically, these were the development of a beam neutralizer, lightweight magnetic optics, beam sensing and bore sighting methods and a sensor to measure the effect on the target.[94] In 1993, officials reported that "the program [had] made rapid progress and the last remaining technology demonstrations are being completed."[95] Budget cuts in the SDIO program ultimately resulted in the redirection of the directed energy efforts, with greater emphasis placed on laser technology.

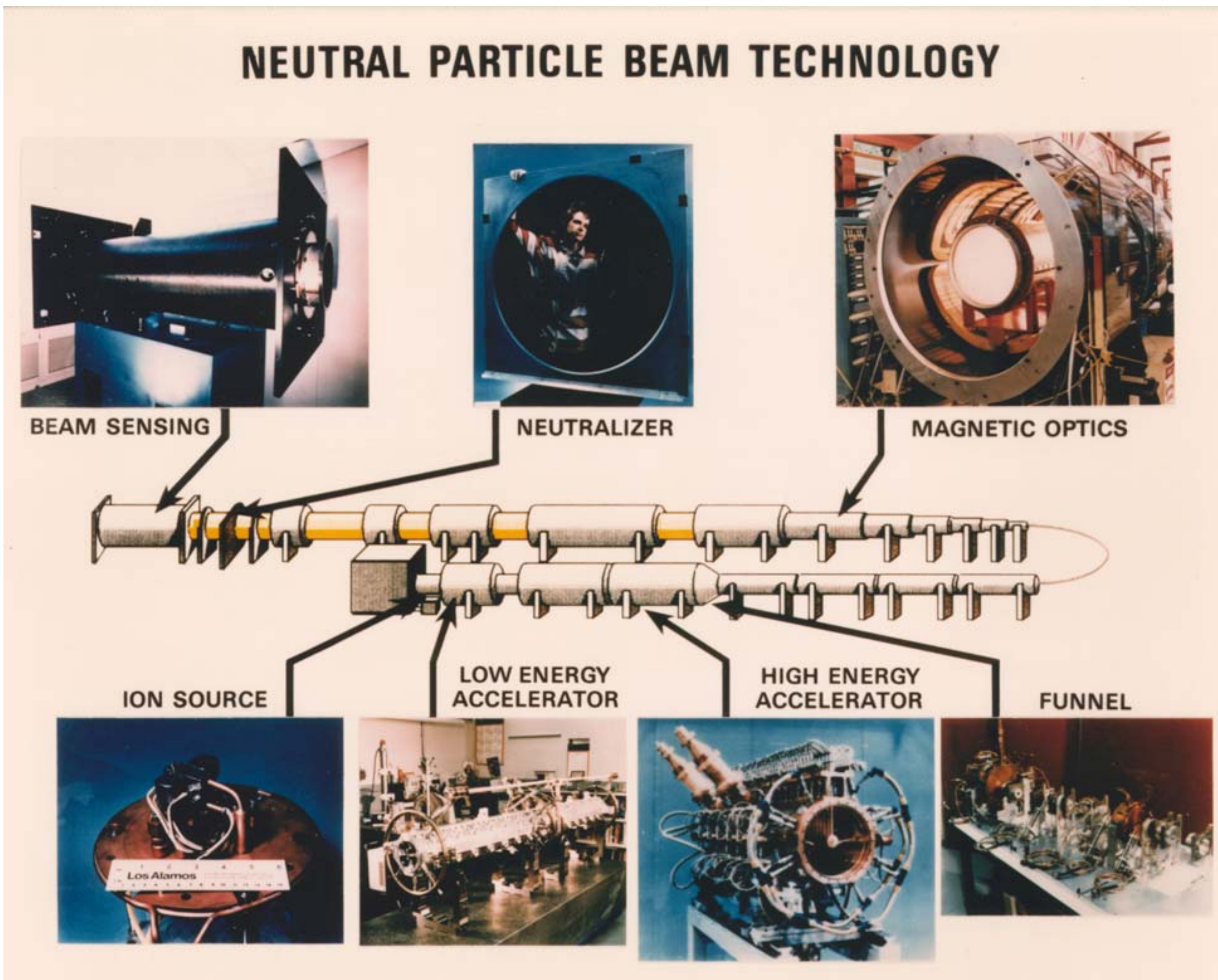
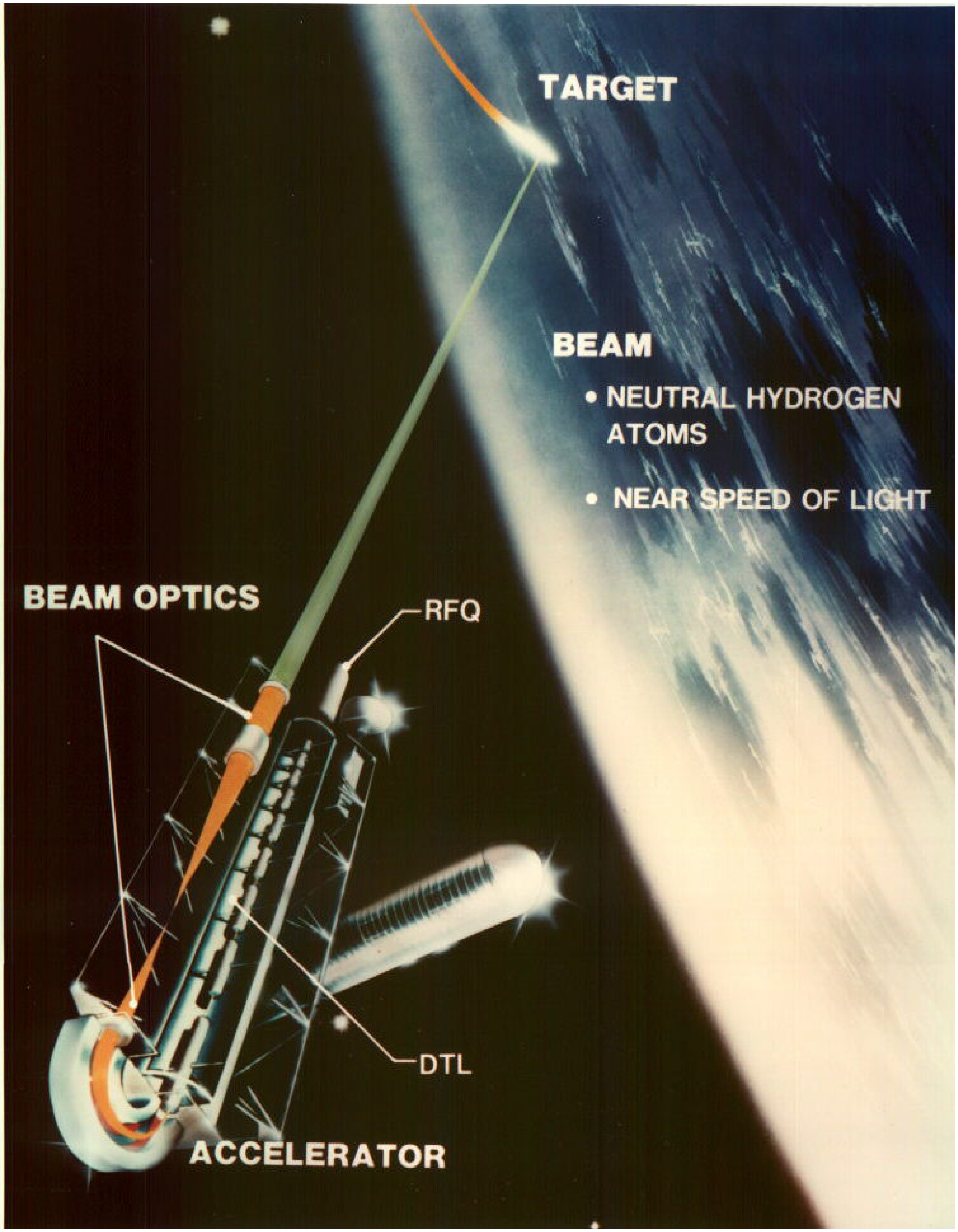


Fig. 3-20 and 3-21. By 1993, many of the Neutral Particle Beam technologies had reached maturity. The diagram above shows the elements of an NPB and their place in the finished product. A deployed NPB (depicted on the facing page) would be a space-based system which could shoot hydrogen molecules at about 60,000 kilometers per second.


TARGET
BEAM
• NEUTRAL HYDROGEN ATOMS
• NEAR SPEED OF LIGHT
BEAM OPTICS
RFQ
DTL
ACCELERATOR

SDI-Midcourse Phase

Exoatmospheric Reentry-vehicle Interceptor Subsystem (ERIS)

According to the initial SDIO system architecture, the interceptor for the midcourse phase was the ERIS, renamed the Ground-Based Interceptor (GBI) in 1990.[96] Based on the results of the High Altitude Defense Study, conducted in fiscal year 1983, the USASDC created the ERIS Project Office on 1 July 1984.[97] The SDIO subsequently identified the program as a high priority effort in 1986. Its mission was to resolve technical issues associated with the development of lightweight, low-cost, non-nuclear interceptors for midcourse defense. In addition to these concept definitions, the ERIS project was tasked to develop "key components, including miniaturized seeker/optics, advanced propulsion and controls and innovative low-cost avionics and terminal maneuver propulsion and controls."[98]

ERIS - FTV Flight I Intercept, 20 January 1991

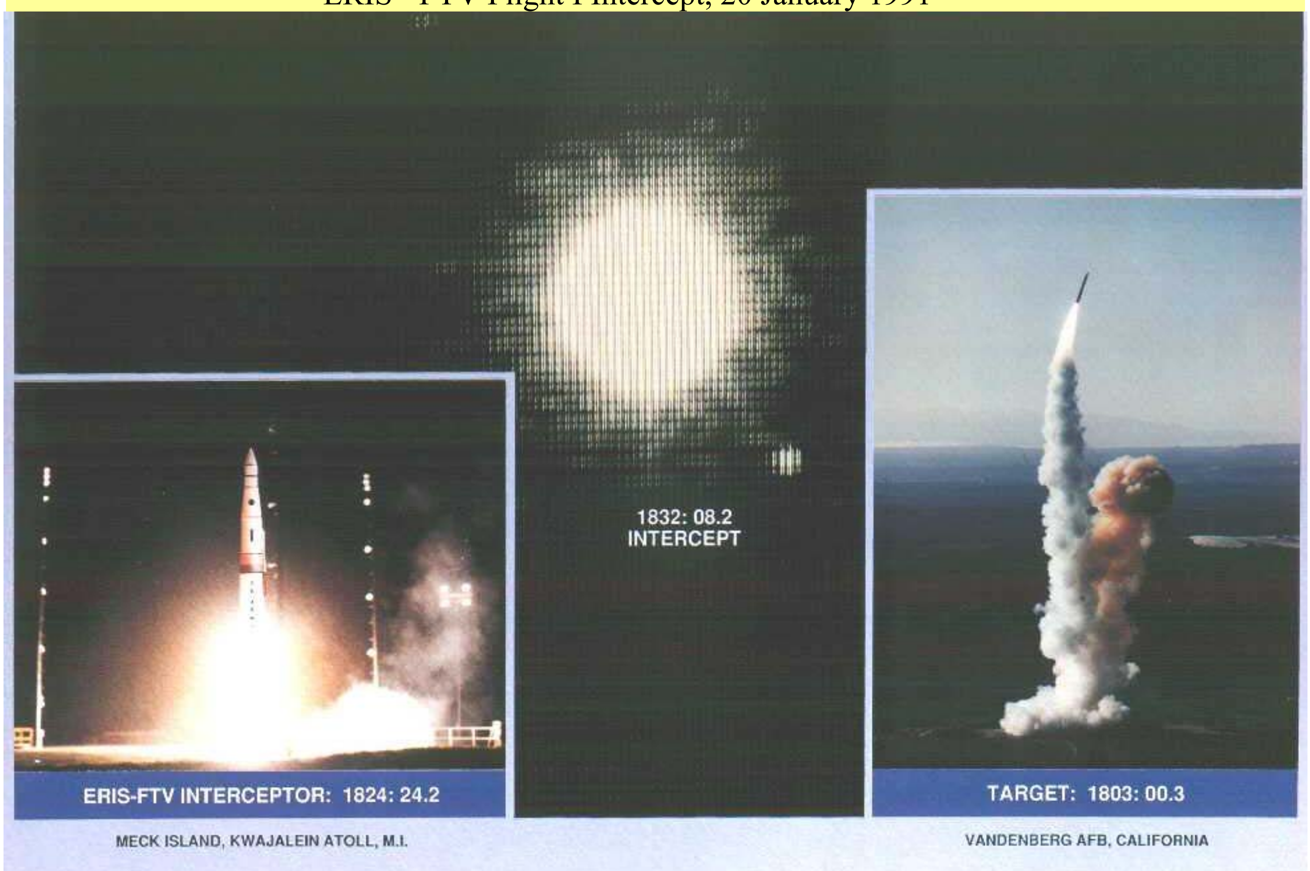


Fig. 3-22. The Exoatmospheric Reentry-vehicle Intercept System was the first SDI project to achieve an intercept as seen in this collection of photographs from January 1991.

Employing some of the technology from the Homing Overlay Experiment and existing materials, development of the ERIS system began in 1985 with the contract award to Lockheed Missiles and Space Company. Constructed of surplus Minuteman ICBM second and third stages, the experimental ERIS missile would incorporate a kill vehicle with an LWIR scanning seeker, a data processor and flight divert attitude control propulsion motors in a two stage rocket booster.[99] The 160-kg ERIS interceptor would receive information from external sensors and, based on this data, select the appropriate target by comparing flight signatures.[100]

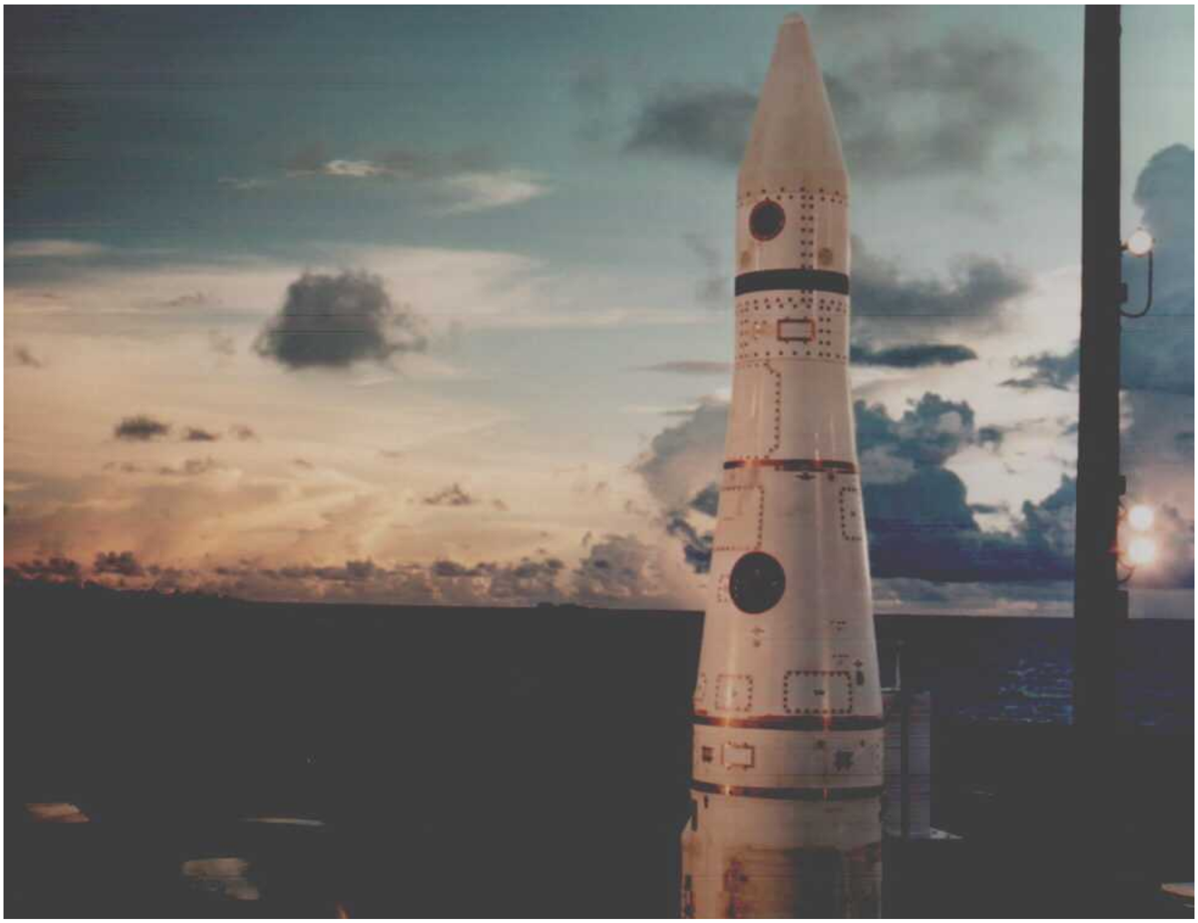


Fig. 3-23. ERIS at sunset, before a test flight.

The first major milestone of the ERIS functional technology verification program was met in April 1989, when the integrated system test vehicle left the manufacturer's facility to begin the test phase. There was another two years of testing before the first flight test. Nevertheless less than a decade after the HOE intercept, on 28 January 1991, launched from an underground facility on Meck Island in the Kwajalein Atoll, the ERIS test vehicle successfully detected the target amidst decoys, and intercepted the mock ICBM warhead launched from Vandenberg AFB. The test, "the first time an SDI experiment attempted an interception in a counter-measures environment," exceeded expectations for this initial mission.[101]

The second and, due to budget cuts, final test was conducted on 13 May 1992 against a Minuteman I ICBM. The primary focus of this effort was in data collection on the guidance, acquisition, track and divert functions. Although a direct intercept was not achieved, the mission met its objective of demonstrating target handover, acquisition and resolution of threat and the collection of radiometric data on the target and decoys.[102]

SDI-Terminal Phase

Airborne Surveillance Testbed (AST)

The Ballistic Missile Defense Organization selected Boeing as the prime contractor for the Airborne Optical Adjunct, later renamed the Airborne Surveillance Testbed, in July 1984.[103] The project was chartered later that year. The purpose of the AST was to prove that "an infrared sensor, data processor, and associated communication links, can be integrated on an aircraft."[104] Perhaps more importantly, the effort was to show how this system could be used "to acquire, track, discriminate, designate, and hand over track data on ballistic missile threats in real time to a ground-based radar."

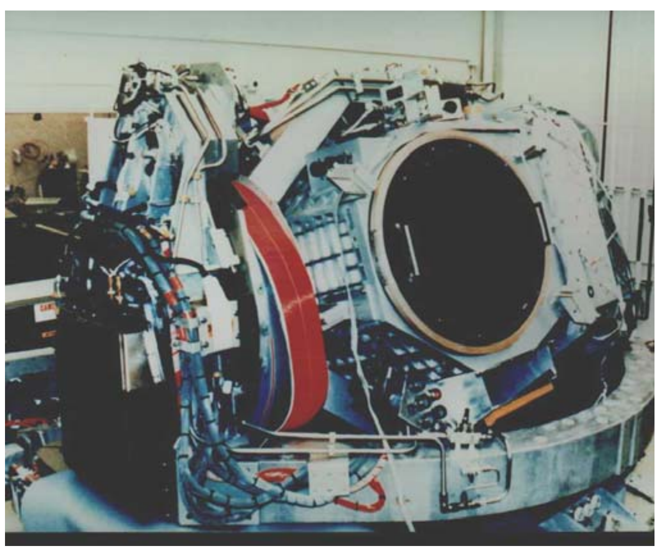


Fig. 3-24. The 5,000 pound sensor with its 38,400 detectors which flies aboard the AST aircraft.

In 1987, the AST became the first element of the terminal phase and the SDI program itself to enter the test phase. In August 1987, the modified Boeing 767, with its 86-foot long cupola, passed its first airworthiness tests. In July 1988, Hughes Aircraft Company delivered its sensor, the most complex, long-wavelength infrared sensor built to date. The integration and installation process began in preparation for the 1990 mission fight tests.[105] These tests successfully demonstrated the feasibility of the airborne seeker.

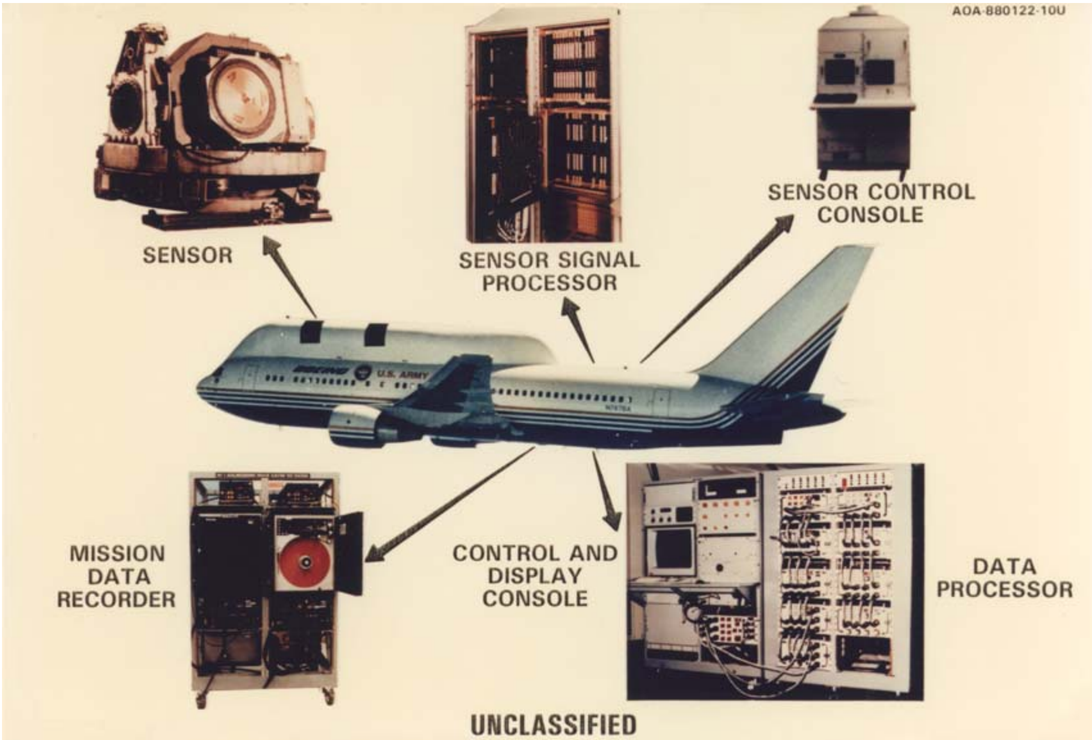


Fig. 3-25. The Airborne Surveillance Testbed, an airborne system with its heat detecting telescope, remains an important asset to Army data collection efforts.
This diagram illustrates the various components of the AST system.

The AST program further demonstrated its capabilities on 29 June 1991 in a seven-hour mission. During this flight, the AST performed its first real-time discrimination of multiple reentry-objects.[106] Despite the frequent threat of termination due to cost growth, the AST moved from the developmental to the experimental phase. The AST continues to provide optical and tracking support to the command and other services.

Ground-Based Radar (GBR)

As mentioned above, the AST would hand over data to a GBR facility.[107] This project began in 1984, as the BMD Radar Project Office. In 1986, it was renamed the Terminal Imaging Radar (TIR) Project Office and assigned the mission "to develop and validate an ABM treaty compliant defense radar technology testbed that [can] perform high altitude discrimination in real-time."[108] This phased array radar would have the ability to relay data to the various interceptor subsystems. In addition, by operating in the X-band, the system will be able to "propagate thru rain… [and] nuclear effects," ensure the measurement precision need for discrimination, and "defeat jammers and chaff."[109]

Fiscal year 1988, saw further developments in the program with the addition of a GBR-Experiment (GBR-X),[110] to be constructed at USAKA, and a GBR-Midcourse, still in the conceptual stage. At the same time SDIO ordered that the project office be redesignated the GBR Project Office. On 15 June 1990, the Defense Acquisition Board granted the SDIO and GBR approval to move into the demonstration and validation phase, beginning a series of experiments and testing on the radars.[111] It remained to be decided, however, whether to have mobile or fixed-based facilities.

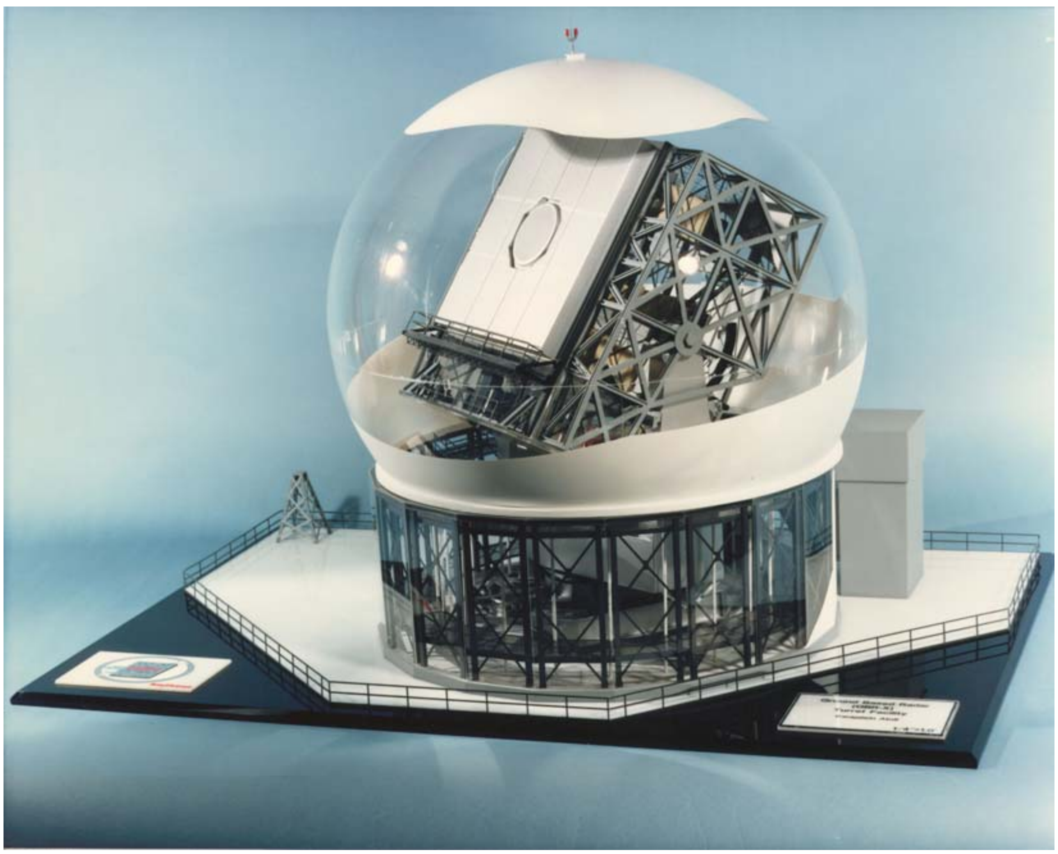


Fig. 3-26. Model of the turret facility of the Ground-Based Radar-Experimental planned for Kwajalein.

Ground-Based Surveillance and Tracking System (GSTS)

Another element in the terminal defense stage of the Strategic Defense System is the GSTS.[112] At the urging of the Defense Acquisition Board, the GSTS Project Office evolved out of a research effort initiated by the Systems Analysis/Battle Management Directorate. Established on 14 November 1988, the aim of the Project Office was "to design and fabricate an LWIR sensor housed in a ground-launched rocket that could locate, track and discriminate real targets from decoys in the event of a ballistic missile attack."[113]

In October 1988, McDonnell Douglas Space Systems Company won the contract to manufacture and test its design for "a reusable, fully flight qualified sensor payload and a ground-based data processor."[114] Funding limitations put some constraints on the options being explored, but production continued steadily towards the series of flight tests planned for fiscal year 1996. Nevertheless, the 1992 decision by Congress to defer deployment on the proposed National Missile Defense site and limited funding to the SDIO resulted in the termination of the GSTS.[115] Ambassador Henry Cooper, SDIO Director, signed the termination letter on 8 October 1992.

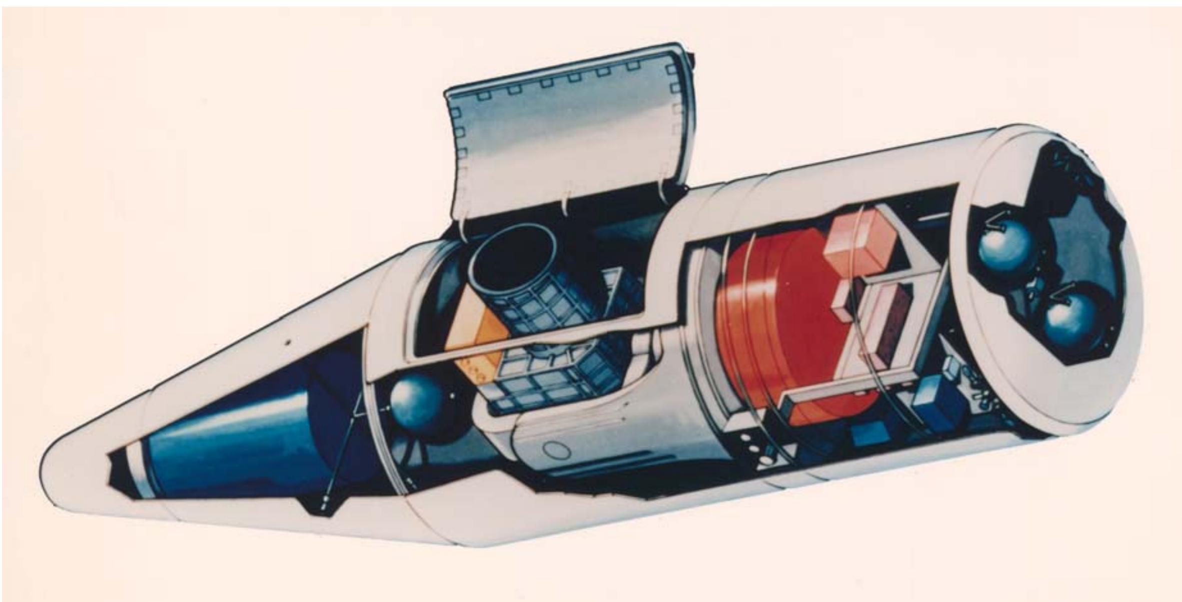


Fig. 3-27. Terminated before flight tests could be conducted, this drawing shows the sensors in the payload section of the Ground-Based Surveillance and Tracking System.

High Endoatmospheric Defense Interceptor (HEDI)

The interceptor designed for this terminal phase[116] was the High Endoatmospheric Defense Interceptor (HEDI).[117] Originating from a study on high altitude defense, this Project Office was created on 20 February 1985.[118] Its goal was to develop a nonnuclear interceptor capable of destroying an ICBM reentry vehicle within the Earth's atmosphere, operating at altitudes between 50,000 and 200,000 feet.

The HEDI Project Office and its contractor, McDonnell Douglas Corporation, made steady progress in the program until 1989, when budget cuts forced the redirection of the contract. Several tests were, at that time, either altered or deleted from the schedule.[119] In many respects, the HEDI project became a technology demonstration program.

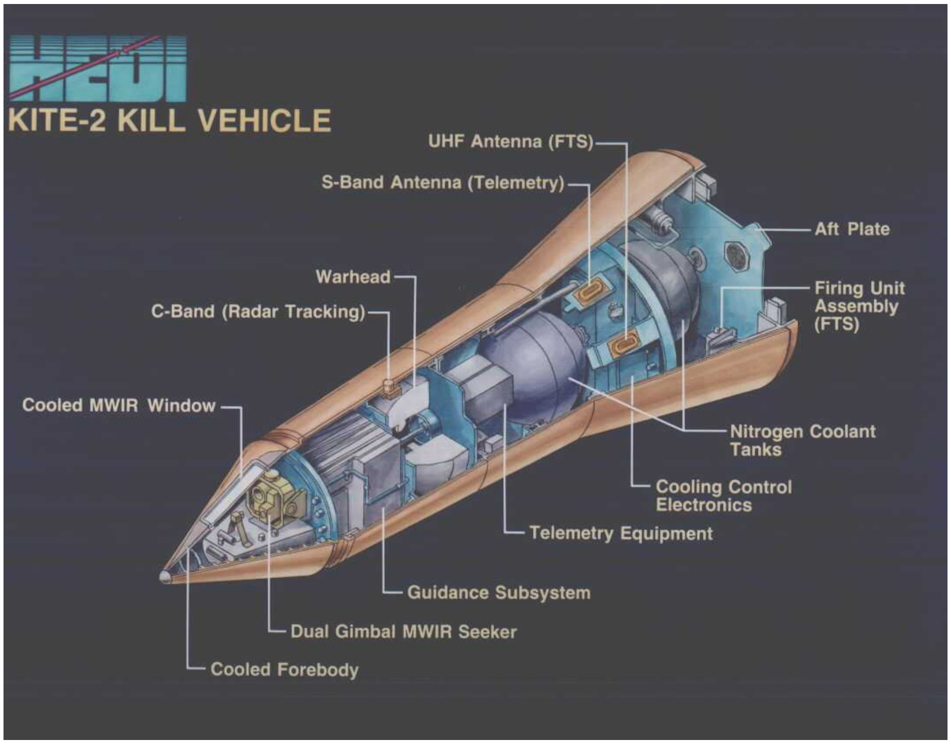


Fig. 3-28. The High Endoatmospheric Defense Interceptor incorporated a number of innovations as seen in this cut-away drawing.

Despite these cuts, on 26 January 1990 the HEDI Project Office conducted its first flight test at White Sands Missile Range. The Kinetic Kill Vehicle Integrated Technology Experiment (KITE), which self-destructed prematurely, still succeeded in demonstrating the viability of "the nose cone shroud and on-board seeker window."[120] This and other tests ultimately proved the feasibility of the shrouded sapphire window technology, cooled optics, two color seekers, advanced propellants, and other innovations.

During the summer of 1990, SDIO Director Ambassador Cooper approved the Endoatmospheric/Exoatmospheric Interceptor (E^2I) program as a "logical follow-on to the HEDI KITE program."[121] At the same time, HEDI was identified as a "viable candidate for the lead ground-based interceptor for the SDS [Strategic Defense System] architecture." Using both a medium wavelength and an LWIR seeker, the E^2I would expand the range of SDI's terminal defense interceptor from "tens of kilometers to hundreds of kilometers."[122] In September 1991, the KITE-2 test again prematurely detonated, the KITE-2A flight, however proved successful. On 25 August 1992, the KITE-2A gathered data on all the required objectives, proving that "the necessary technology is in hand to perform an intercept of reentry vehicles within the earth's atmosphere using an infrared homing seeker and a non-nuclear warhead."[123] Despite these successes, officials favored interceptors above the earth's atmosphere, and the subsequent budget constraints led to the termination of the HEDI project office at the end of fiscal year 1992.[124]

Fig. 3-29. The rail-launched High Endoatmospheric Defense Interceptor missile achieved a successful intercept in this Kinetic Intercept Technology Experiment 2A conducted on 25 August 1992.

ABM Treaty Interpretations

As the United States began to move forward in the development of a new missile defense system, opponents questioned the compliance of the proposed SDI system with the 1972 ABM Treaty. Initially, the Reagan Administration held that the proposed research programs involved only subcomponent testing and was therefore allowed under the treaty. Soviet President Mikhail Gorbachev, however, disagreed, calling the proposed program illegal.[125]

In July 1985, President Reagan presented an address to the nation on the Strategic Defense Initiative. Quoting Soviet Marshal Grechko's 1972 testimony to the Supreme Soviet, Reagan argued that "the treaty on limiting ABM systems imposes no limitations on the performance of research and experimental work aimed at resolving the problem of defending the country against nuclear missile attack."[126] In 1985, following a lengthy review of the treaty, the Reagan administration concluded that a "broad" interpretation was valid. As introduced by U.S. National Security Adviser Robert McFarlane, on 6 October 1985, space-based and mobile ABM systems and components that are based on "other physical principles" (i.e., lasers, particle beams) may be developed and tested but not deployed. According to the administration, these technologies are not covered by the treaty, as they did not exist when the treaty was written. They are thus addressed in Agreed Statement D, which stated that "specific limitations on such systems and their components would be subject to discussion."[127]

Strategic Defense System Phase I

At the end of 1986, officials decided to enter a missile defense system, to be deployed in the early 1990s, into the defense acquisition process. The Strategic Defense System (SDS) Phase I was the product of this decision. In 1987, the Defense Acquisition Board conducted two reviews of the SDI program, which concluded in part that "'there is presently no way of confidently assessing' the system's price or its effectiveness."[128] Nevertheless based on the overall DAB assessment, in September 1987, Secretary of Defense Caspar Weinberger approved the SDS Phase I baseline architecture and authorized six components of SDI to enter Demonstration/ Validation phase.

The six Phase I components included a space-based interceptor, a ground-based interceptor (the ERIS), a ground-based sensor (the GSTS), two space-based sensors (the boost surveillance and tracking system and the space-based surveillance and tracking system), and a battle management system. With this layered deployment, the architecture concept would provide a defense against Soviet missiles in all stages of their flight. There were however two drawbacks to the proposal: it was costly, and the space-based elements were vulnerable to Soviet anti-satellite systems. To enhance survivability, the SBI was replaced in1990 with the Brilliant Pebbles concept of 300 orbiting interceptors.[129] With the adoption of Brilliant Pebbles, the requirement for a boost surveillance and tracking system was also eliminated.

Other USASDC Initiatives

As these programs evolved from the theoretical to the demonstration stage, the command continued to explore new areas in interceptor, sensor and related technology.[130] Advances have been made in the realm of optics, sensors and data processing, which have subsequently been applied to existing and planned systems. The DEW Directorate continued work on a variety of lasers and neutral particle beams. At the same time, they sought to develop rapid retargeting technology, laser radar, and phased array mirror capabilities.

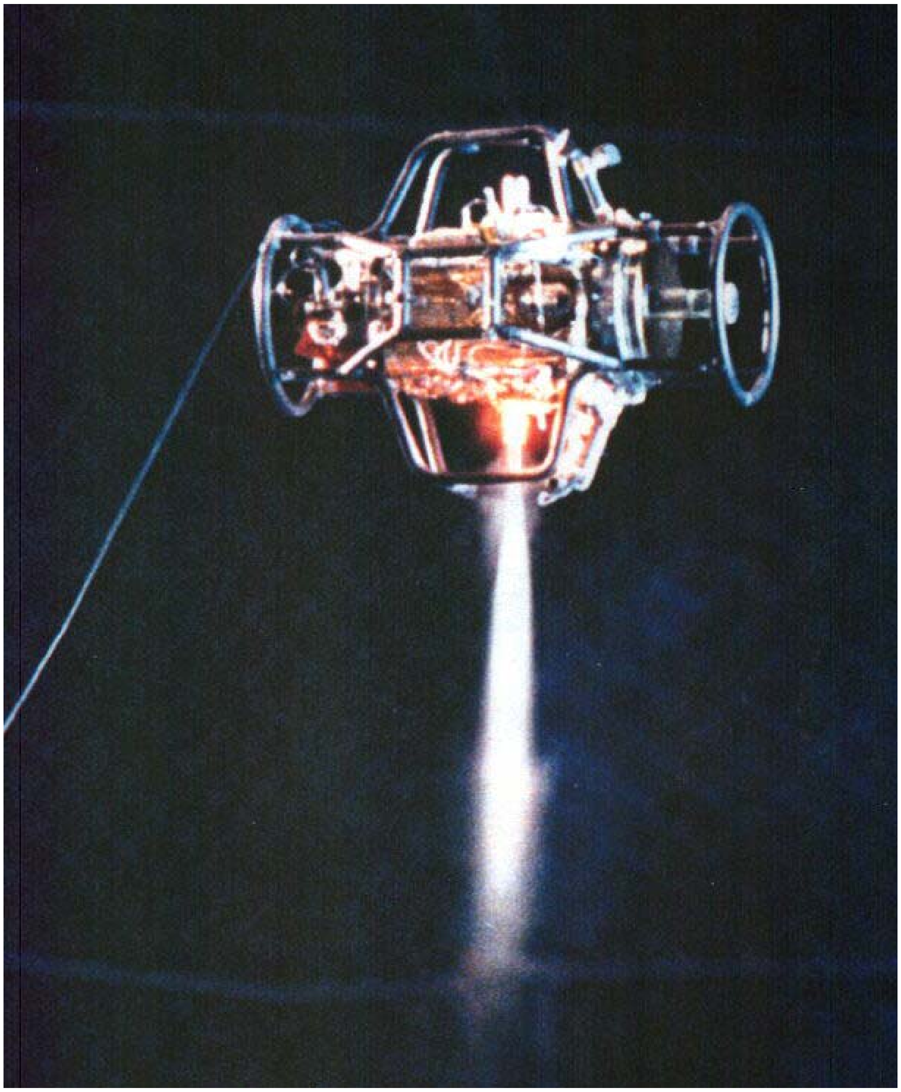


Fig. 3-30. State of the art technology is proven as the Lightweight Exoatmospheric Projectile tracks a simulated target in this hover test.

In addition to the electrothermal gun and hypervelocity launcher, the KEW Directorate worked on a D2 projectile. With regard to miniaturization, they produced the Lightweight Exoatmospheric Projectile (LEAP), a miniaturized infrared sensor system and kill vehicle for ground or space-based rockets.[131] The LEAP successfully performed a required hover test on 18 June 1991. They subsequently conducted several productive flight tests, but had not completed an intercept.[132] Transferred to the Navy in 1993, the LEAP continued to be tested as part of the Navy's Terrier/LEAP program. Four flight tests conducted between 1992 and 1995, demonstrated that the LEAP could be integrated into a sea-based tactical missile for exoatmospheric BMD.[133] As a result, the LEAP technology formed the basis of the Navy Theater Wide program.

Anti-Satellite (ASAT)

On January 6, 1989, the Defense Acquisition Board authorized the development of an Anti-Satellite (ASAT) program for deployment in the mid-1990s.[134] In March, the Army, "based largely on the Army track record with ground-based interceptors," was given the lead in this joint service effort which included both the Navy and the Air Force.[135] The program was initiated to counteract an already deployed Soviet ASAT system that proponents argued, "held many of our critical intelligence and communications satellites at risk"[136] To address this threat, the DAB requirements included both kinetic energy (KE) and directed energy (DE) approaches.

As a Department of the Army-funded program, the ASAT was distinct from the SDI effort. Nevertheless it did draw upon the KE and DE research conducted by the USASDC and its contractors. Thus SDI funding, as in the case of laser research, directly impacted the ASAT development.[137] Despite the delays in DE-ASAT progress, the KE-ASAT continued with only a few setbacks. The proposal for two versions of a KE-ASAT, one ground-launched, the other sea-launched, was however scaled back to one. In August 1990, the USASDC awarded a demonstration/validation contract to Rockwell International Corporation, to develop a ground-launched KE-ASAT.[138] The first tests for a component of this single site system, a visual light sensor, were planned for January 1992. Following significant budget reductions in 1991, and program restructuring, the Army recommended cancellation of both ASAT programs.[139] Funding for the KE-ASAT was restored after several prominent senators wrote to President George Bush in support of the effort. In fiscal year 1992, the Congress directed that the ASAT program be "updated to reflect the lack of a Soviet threat and the proliferation of militarily significant space capabilities to a growing number of countries throughout the world."[140]

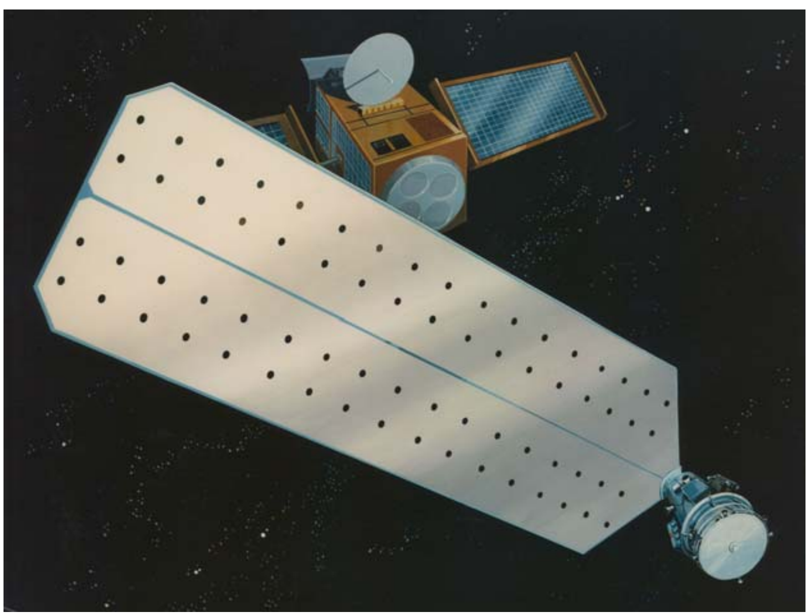


Fig. 3-31. This drawing illustrated the concept of a kinetic energy intercept of a satellite.

By June 1993, continued budget cuts had forced the termination of the KE ASAT Joint Program Office. The Defense Authorization Act for fiscal year 1994, however, directed that the program should be converted into a technology program, managed by the command.[141] The ASAT program continued, although at a slower rate. The work culminated in a hotfire strapdown test, conducted in September 1995. This test demonstrated the kill vehicle's ability "to 'fly' a pre-determined simulated flight path by firing its divert/attitude control system thrusters." The system also successfully acquired and tracked the target with its on-board computers. Two years later, the prototype concluded a successful hover test, in which the sensor acquired and locked onto a simulated moving target.[142]

The KE-ASAT program experienced repeated funding problems throughout its history resulting in program rescheduling and other setbacks. In 1998, the U.S. Space Command's Mission Needs Statement for Space Control included a requirement for an ASAT capability. In the same year, however, President Bill Clinton used a line item veto to eliminate funding for the ASAT and 42 other programs. This action was subsequently deemed unconstitutional by the U.S. Supreme Court and funding was restored. Surviving on Congressional plus-ups, the KE-ASAT program transferred to the U.S. Army Aviation and Missile Command effective October 2001.

High Energy Laser Systems Test Facility (HELSTF)

In 1974, the United States Congress directed the Department of Defense to create a "national" tri-service high energy laser test facility, to address the "proliferation of site development work at various government and contractor facilities."[143] DoD awarded a contract in 1981 for the construction of the site at White Sands Missile Range, New Mexico, and by 1984 it was nearly complete. The mission of the High Energy Laser Systems Test Facility (HELSTF) was to support Army and DoD laser research and development, test and evaluation. It is also to integrate and operate lasers and related instrumentation, facilities, and support systems and conduct and evaluate laser effects tests on materials, components, subsystems, weapons and systems.[144] The HELSTF became operational on 6 September 1985 with an Air Force Lethality and Target Hardening program experiment for the SDIO. In this test, the Mid-Infrared Advanced Chemical Laser destroyed a Titan booster rigged to simulate the conditions of a thrusting rocket booster.

In October 1989, Secretary of the Army Michael P.W. Stone directed the transfer for the HELSTF from the Army Materiel Command to the USASDC, in order to centralize high energy laser research within one command. The actual transfer came one year later on 1 October 1990.[145] Under this new leadership, the mission of HELSTF expanded to include a full range of research, development, test and engineering functions to include test and evaluation, laser damage and vulnerability support, intelligence evaluation resources, advanced system integration center, range instrumentation, space surveillance, and anti-satellite contingency capability.[146] The HELSTF site has been instrumental in the command's subsequent directed energy programs.

The Army Returns to Space: New Organizations

As the Army continued to make progress in missile defense, experimenting with anti-satellite weapons systems as well as laser and particle beam weapons, its long dormant interest in space-based systems began to revive. Because there was not an already existing critical mass of interest for space as there was for missile defense, the way forward was more difficult. First, the Army had to reinvigorate its interest and learn to recognize space-based systems as force multipliers.

In 1983, the Army Science Board's study *Army Utilization of Space Assets* concluded the Army was not using space systems to their full potential. The study concluded that to achieve better exploitation of space systems there must be a high-level commitment backed by sufficient resources. Operation Urgent Fury, the 1983 invasion of Grenada, highlighted the scramble for limited space assets between different services and government levels. The Army had relied on the systems fielded by the other services too long, and frequently received the "leftovers" in a crisis situation. The Combined Arms Grenada Work Group recommended the Army develop, own, and control its own satellites to assure critical communications in such operations.[147] Later in 1983, an Army Space General Officer Working Group was founded to provide direction for Army space efforts.[148] In 1984, the Army Science Board studied the Army's use of space to support its missions, concluding the Army made limited use of space assets and was neither active nor influential in designing and operating most of the space systems then in use. In August 1984, an Army Space Council was created as a coordinating body to approve proposals and provide direction for the Army's involvement in and use of space. The Council met in Washington and coordinated programs that were divided among various staff offices organized by function.

In September 1984 the Vice Chief of Staff of the Army (VCSA), General Maxwell Thurman, activated an Army Staff Field Element at AFSPC headquarters, the nascent form of the U. S. Army Space Command (USARSPACE). The Field Element acted as liaison to AFSPC and initiated planning for Army participation in the unified U. S. Space Command. The Staff Field Element was also responsible for exchanging information about space policy, strategy and plans, monitoring Army space-related education and training developments, representing the Army Space Office at HQ Space Command and providing technical information to Space Command regarding Army space efforts. In October 1984, the Army Space Council met to discuss the Army's emerging role in space and produced guidance for future Army efforts. The Army assembled a staff organization to manage its space activities after the other services. For many years, as the role of space in military operations expanded, the Army's interest and influence decreased, but this would change.

By the end of 1984, the Army Management Structure for Space had four components: (1) an Army Space Council chaired by the VCSA; (2) the Army Space Working Group, chartered to support the Space Council with recommendations and act as its coordinating body; (3) the Army Space Office, part of the ODSCOPS, serving as a focal point for space-related matters serving as a liaison to the Joint Staff and the Office of the Secretary of Defense; and (4) the Army Staff Field Element of AFSPC. The Army Space Office identified five high priority tasks: (1) developing an Army space policy, (2) creating an inventory of existing Army space-related requirements and programs, (3) crafting "near-term enhancements" to Army space involvement in "key areas," (4) developing "Army space-related requirements based on an operational concept for space support to warfighting," and (5) developing "Army options to support a potential unified command for space."[149]

The Army Space Institute and the Army Space Agency

Army space activity increased and reached a critical mass in 1985. In January of that year, the Training and Doctrine Command (TRADOC) directed that the Combined Arms Combat Development Activity (CACDA) form a Space Directorate. Rearranging resources, the directorate was duly formed and given responsibility for developing concepts, doctrine and operational requirements to make the best use of space to support operations. In May, the VCSA, General Maxwell Thurman, directed an Army Space Initiatives Study (ASIS) Group be formed to analyze the Army's role in space and the ways it should use space. In August, CACDA's Space and Concepts Directorates published "Army Space Operations." In September 1985, the Staff Element at AFSPC was renamed the Army Space Planning Group and became the Army element of the newly formed U. S. Space Command. The Army Space Planning Group was under the operational control of the new unified command, but remained subordinate to the Army ODCSOPS.

In 1986, the Army Space Planning Group became the Army Space Agency.[150] The name change did not affect the organization's mission. It would still "assist USCINCSPACE in planning enhancement of space support to ground force components in AirLand Battle doctrine and mission requirements" and "provide Army input to the strategic defense planning process," while providing "support to TRADOC's requirements, concepts and doctrine work." It would also be an "operationally oriented point of contact at USSPACECOM for the U.S. Army Strategic Defense Command [USASDC], the U.S. Army Space Programs Office [ASPO] and the military satellite communications [MILSATCOM] communities" and "assist the ODCSOPS in determining Army space roles, missions, requirements and master plan development."[151]

Between July and December 1985, the ASIS group, directed by Brigadier General William J. Fiorentino, prepared the Army Space Initiatives Study.[152] The Fiorentino group provided (1) an extensive analysis of space and space-related activities in order to develop an operational concept for Army space activities, (2) a plan to acquire and manage qualified space personnel, (3) an Army investment strategy for space, (4) a management strategy and (5) an implementation plan.[153]

In December, the ASIS group presented the results of its study to the Army Space Council. The published four volume study concluded that if used properly, space systems would increase the Army's mission capabilities along the entire spectrum of conflict. However, the study group found that responsibility for developing, coordinating and using these space capabilities was fragmented among the Army's many commands. The group made more than two hundred recommendations to improve the Army's use of space systems and products.

The Army Space Initiatives Study report contained an investment strategy, educational, training and personnel management recommendations, a suggested Army organization for space, an implementation plan, a technological assessment and projections and a discussion of threats. Specifically, the report advocated making the Office of the Deputy Chief of Staff for Operations and Plans the senior Army staff proponent for space, recommended that the Combined Arms Center at Fort Leavenworth become the Army proponent for space and the Command and General Staff College become the lead Army school for space education. The study urged the formation of an Army Space Command as the Army component of USSPACECOM and advocated the Army integrate the use of space and space products into its doctrine. Concretely, the report called for the creation of a Space and Special Weapons Directorate within the Office of the Deputy Chief of Operations and Plans, establishing an Army Space Institute (ASI), the Army Space Technology Research Office (ASTRO) and the Army Space Agency. The Fiorentino study also counseled making the Army Materiel Command responsible for managing space research and development. In addition, the report advocated conducting Mission Area Analyses to discover the potential uses of space systems and capabilities, training soldiers about space systems and creating an additional specialty indicator to trace personnel with experience, education and training in space systems.[154] The four-volume report did not discuss space-related aspects of ballistic missile defense, anti-satellite weapons, or theater missile defense space issues. In the two years following the report's release many of its recommendations were implemented.

The Army Space Institute was established in June 1986 to serve as a clearinghouse for matters relating to the Army's use of space.[155] Functioning this way, as the TRADOC proponent for space and space systems, it would be responsible for developing Army space concepts, doctrine, training, force structure, materiel requirements, techniques and procedures that would apply space systems and technology to "enhance the execution of AirLand Battle Doctrine and support the Strategic Defense Initiative."[156] The ASI maintained a tactical focus. It consistently concentrated on reaching the small unit commander in order to familiarize him with space systems and their use and provided training and support to tactical units. This approach was markedly different from the ways space systems had been treated before ASI was established. Before 1986, the focus of military space systems was on the strategic level and the systems were dedicated to supporting the missions of the Strategic Command and the North American Air Defense Command. The ASI approached its mission aggressively and predicted that space systems would be available at the battalion and company levels. In 1987, the ASI Commandant predicted a future in which advanced positioning systems would allow commanders to know the locations of their subordinate units continuously, space-based communications systems would make line of sight limitations on ground-based radios meaningless which would allow smaller units to act as a whole even though separated by great distance or rough terrain, and that a battalion intelligence staff section would have instant access to real-time satellite imagery and weather information.[157]

Demonstrating the Utility of Space-Based Systems

Over the next year, working at the direction of the VCSA, General Maxwell Thurman, the Institute prepared for the Army Space Demonstration Program (ASDP). The program would serve as ASI's primary experimental vehicle, to show the ways current space-related products could support battlefield commanders and their units, down to the squad level.[158] General Thurman wanted the program to inform the Army of the ways space-based systems would support AirLand Battle Doctrine and not test the technology.[159] The first four proposed demonstrations included the Global Positioning System (GPS) Receiver Position/Navigation, GPS Azimuth Determination, weather and terrain analysis and lightweight small satellite (LIGHTSAT).[160] The Global Positioning System Receiver Position/Navigation demonstration showed the system's capabilities. The Azimuth Determination demonstration showed how useful it would be to mount GPS receivers on combat vehicles in order to orient them and their associated weapons systems. The weather and terrain analysis demonstration provided corps and division commanders with weather support using WRASSE commercial weather receiver systems. LIGHTSAT was intended to demonstrate and evaluate the operational value of lightweight, relatively inexpensive, limited purpose satellites and associated expendable booster vehicles as a cost effective method of providing space-based support to operational and tactical commanders throughout the world. Among the uses envisioned for LIGHTSAT were reconnaissance, intelligence collection, surveillance and target acquisition (RISTA). The lessons learned garnered from the demonstrations would be used to help design future systems.

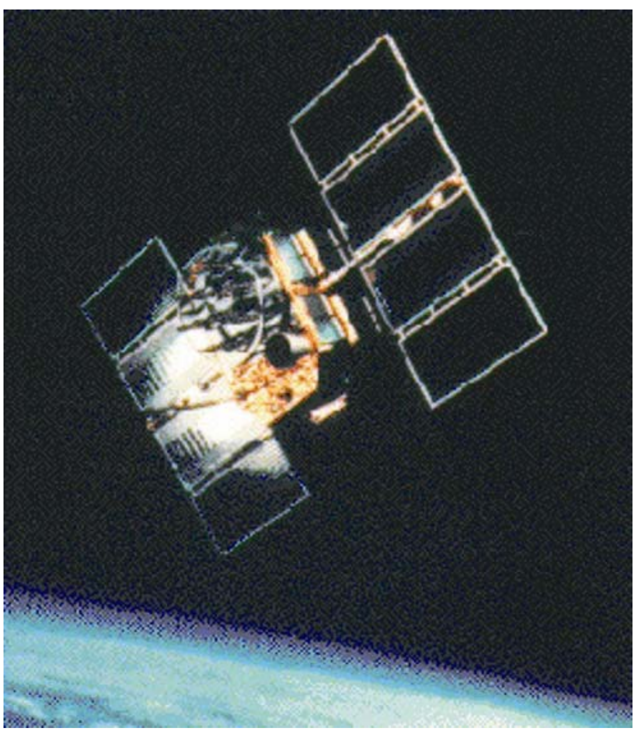


Fig. 3-32. Artist's drawing of a Global Positioning System satellite.

Fig. 3-33. Drawing of a GPS satellite web.

Fig. 3-34. Drawing of a Military Strategic Tactical and Relay 3 satellite.

By 1989 the new equipment's capabilities had been demonstrated to some Army commanders and units. The first equipment items shown were the Small Lightweight GPS Receiver (SLGR), the WRAASE weather receiver and AN/PSC3 TACSAT radios. The SLGR was a handheld receiver that gave accurate position and navigation data to tactical users. The weather receivers, deployed to Air Force weather teams supporting divisions, separate brigades and other units, used the network of weather satellites to provide them with accurate weather forecasts. The tactical radios could relay and transmit voice and data messages directly between users in the same theater of operations or store and forward messages anyplace in the world using the network of geosynchronous communications satellites. In addition, the research and development undertaken to use GPS to determine accurate azimuth information led to the creation of prototype receiver/processors with special antennae.[161] By August 1990, the objective that General Thurman established for the Army Space Demonstration Program was being realized. After Iraq invaded Kuwait, threatened Saudi Arabia as well as other Persian Gulf states and the stability of a substantial portion of the world's energy supply, a coalition led by the United States deployed troops first in Operation Desert Shield and then in Operation Desert Storm. Many of the tactical units deployed to the Gulf participated in the Army Space Demonstration Program and now wanted this equipment.

The Army was also coming to grips with the issue of developing space expertise. As it re-entered space and participated with the other services in USSPACECOM, personnel managers realized that trained officers would have to fill space-related positions in the new Army Space Agency and on Army staffs. Personnel managers needed to develop the expertise while they were creating the positions to justify the appropriate training programs. The ASI had to develop the training at the same time its combat development actions began to define what training was necessary. In 1986, shortly after the space activities skill code was established, ASI proposed to redefine it, while realizing this did not address the basic need to build expertise.[162] In 1987, a new Space Activities skill code definition was sent to the VCSA with more specific qualifications in duty assignment, military training and civilian schooling.[163]

The Army Astronaut Program

The Army had long had an interest in manned space flight. In January 1959, NASA dealt a blow to the Army's hopes for continued involvement in space exploration when it published the selection criteria for astronauts from the military services. One requirement, stipulating that an astronaut be an experienced jet aircraft pilot, eliminated Army personnel from consideration as astronaut candidates.[164] In 1964, NASA dropped the requirement for pilot experience for crew members, but only in an effort to recruit "scientist-astronauts" to conduct research on space flights. Most of these candidates had superior academic qualifications, usually a doctoral degree in the natural sciences, medicine or engineering, or equivalent experience.[165] Because few of its officers had advanced training in these fields, the Army once again found itself excluded from the manned space program.[166]

Undaunted by these developments, Army commentators and officials continued to press NASA to assign Army officers as astronauts. In a 1968 article in *Military Review*, Major Thomas C. Winter, Jr. argued that the Army should be part of a Manned Orbiting Laboratory, which the space program thought it would deploy in the early 1970s. Using equipment originally designed for the Apollo flights, the program would place a manned laboratory in earth orbit for as long as six weeks at a time. Proclaiming control of space crucial to the national interest, Major Winter contended the Army should enter this program to sponsor scientific research to support its missions. He advocated that selected Army officers pursue graduate schooling for doctoral degrees in space-related disciplines at leading universities to acquire the necessary knowledge and experience to become astronauts. He also recommended that the officers spend time working in the NASA Apollo applications program conducting research and acquiring proficiency in crucial skills.[167]

Senior Army leaders echoed Major Winter's sentiments. In February 1969, General William C. Westmoreland, the Chief of Staff of the Army, took up a similar line of reasoning in a letter to Dr. Robert R. Gilruth, Director of NASA's Manned Spacecraft Center in Houston, Texas. After congratulating Dr. Gilruth on his many accomplishments, Westmoreland voiced concern that the Army still lacked representation in the astronaut program. Emphasizing that the Army had more than 18,000 qualified aviators, the general expressed the conviction that "these men are capable of absorbing the training in the pilot-astronaut program and of contributing to the expanding projects in space exploration." He encouraged the NASA director to review his space projects and the criteria for selecting astronauts to ascertain how the Army might increase its participation in the program.[168]

Gilruth's response held out slim hope for General Westmoreland. The NASA director pointed out that NASA already had enough astronauts for the Apollo flights and until it identified future manned space missions it did not intend to select any more astronauts.

However, he noted that future space crews would incorporate a variety of disciplines, including pilots, engineers, scientists and physicians, for which the Army could easily supply talented candidates. Despite the director's reassuring tone, the Army would wait ten years before one of its officers entered the astronaut program.[169]

In January 1978, NASA announced the selection of 35 new astronaut candidates for the Space Shuttle Program, the first chosen since 1969. This group included the first women and racial minorities chosen; additionally, two new astronaut job titles were created, pilot and mission specialist. Both civilians and military officers were among the candidates; one of the latter was Major Robert L. Stewart, who would become the Army's first astronaut.

Events leading to the formation of this group of astronauts began in the late 1960s as NASA officials began to develop plans for a reusable launch vehicle and orbiter to put people in space. This concept evolved into the shuttle, a space plane that would carry astronauts into orbit and return them safely to earth. NASA viewed the shuttle as an inexpensive way to launch people, satellites, probes, an orbiting station and military hardware into space.[170]

Fig. 3-35. Robert Stewart, the first Army Astronaut, a few meters from the Space Shuttle Challenger, floating untethered.

Major Stewart, along with the other 34 candidates, began a rigorous training and evaluation period at the Johnson Space Center in Houston for assignment to future space shuttle flight crews. After clearing this initial hurdle, Stewart and his colleagues became astronauts in August 1979. Stewart, who held a Master of Science degree in Aerospace Engineering, emerged from the training as a mission specialist, responsible for shuttle operations in areas affecting shuttle experiment procedures. Mission specialists conducted space walks, handled payload and maintenance activities and other operations as needed. Mission specialist qualifications included an advanced degree in engineering, life, physical sciences or mathematics, along with specific age, physical and medical requirements.[171]

In December 1976, NASA and the Department of Defense drew up rules governing the assignment of military personnel to the Shuttle program in a Memorandum of Understanding (MOU). The agreement set the tour of duty at five years with the possibility of a one-year extension. At the end of their tours, personnel either retired or resumed duty with their respective services. Any military officer detailed to the shuttle service reported directly to NASA with respect to his astronaut responsibilities. Individual officers remained subject to the Uniform Code of Military Justice and NASA prepared and maintained fitness and effectiveness reports in accordance with the regulations of each member's service. NASA also reimbursed the services for all pay and allowances made to personnel detailed to the agency.[172]

On his initial mission in 1984, Lieutenant Colonel Stewart and another astronaut were the first to perform an untethered space walk using the manned maneuvering unit, or jet pack, on Space Shuttle *Challenger*. He also took part in a classified military mission in 1985. Altogether Stewart logged 289 hours in space. After he left the astronaut corps, he became a brigadier general and deputy commander of the U.S. Army Strategic Defense Command in Huntsville, Alabama. Colonel Sherwood Spring, later head of the Army Space Program Office, became the Army's second astronaut in 1980. As a mission specialist aboard a 1985 shuttle voyage, he launched three communications satellites and performed two space walks to assess construction techniques in space.[173]

Fig. 3-36. Launch of a Space Shuttle flight.

In 1986, the Pentagon established the Military Man in Space program as part of Shuttle operations. The Air Force was the over-all Executive Agent and the Office of the Deputy Chief of Operations and Plans, Department of the Army (ODCSOPS, DA) became the Executive Agent for the Army program. The object of the Military Man in Space Program was to evaluate, through experiments proposed by each uniformed service and approved by DoD, ways in which military operations on earth could be improved using space-related facilities and technologies. In 1987, the Army proposed three experiments that it thought would improve its war fighting capabilities, Terra View, Terra Scout and Terra Geode. These three experiments played significant roles in the future of manned space flight.[174]

Terra View is a four-phase experiment to make observations of ground sites. The first three phases were designed to be conducted on shuttle flights while the fourth phase would be conducted on the space station. Terra View's first phase determined what Army astronauts could detect from space of military value using cameras and binoculars while observing training areas both inside and outside the continental United States. In Terra View's second phase, the Army augmented the astronauts' visual equipment with communications equipment to allow them to pass information directly to ground commanders in real time. Army Colonel Jim Adamson participated in this portion of Terra View. Phase Three used Army experts instead of astronauts to observe ground activity and communicate tactical information to the ground commander. This phase encompasses two other Army Military Man in Space experiments, Terra Scout and Terra Geode. Lessons learned from the site observations and direct communications between the Shuttle and ground sites were used to determine the Army's communications and observation requirements.

The Army Intelligence Center and School developed and sponsored Terra Scout. Its intent was to determine what an experienced imagery interpreter can observe of military value from the Space Shuttle. The Shuttle crewmembers used the Spaceborne Direct View Optical System, an optical device that uses a manual pointing and tracking system with manually controlled zoom lens. Army Astronaut Lieutenant Colonel Jim Voss and Payload Specialist Chief Warrant Officer Tom Hennen performed the first phase of Terra Scout during Space Shuttle Mission STS-44 in November 1991.

In January 1987, the Army Chief of Engineers proposed using a military geologist's observations from earth orbit to evaluate terrain conditions for tactical movement. Terra Geode itself is a four-phase experiment. The results of the first two phases, based on NASA astronauts' observations, helped refine the experiment's design and strengthen the justification for an expert observer to explore potential Military Man In Space applications fully. Military astronauts using standard equipment available to NASA under the Earth Observation Program conducted the experiment's first phase. Dr. Kathy Sullivan, a NASA astronaut with a geology background, conducted the second phase observations during a five day space shuttle mission launched 24 April 1990. She demonstrated the feasibility of terrain analysis from earth orbit and was able to make basic observations of ground targets, determine soil color, type, ground cover, and other terrain data. She also provided guidance for improving the conduct of the next phase of the experiment. Dr. Sullivan completed Phase II of Terra Geode during another shuttle flight into space in 1992. The third phase will be carried out by an Army geologist on the Shuttle and will be the demonstration and validation phase to prove the value of employing the capabilities of a trained expert military observer. The experiment's final phase would integrate lessons learned into possible Army requirements for a space station and for permanently stationing military geologist/terrain analysts there. The Army has selected three officers and one warrant officer as primary, backup and alternate Payload Specialists.

In 1987, as its participation in NASA burgeoned, the Army established an Army Astronaut Detachment at the Johnson Space Center. That same year, the Army formalized its relationship with NASA in a new MOU that governed the assignment of personnel at the astronaut detachment.[175] In 1988, the unit fell under the control of the new Army Space Command (ARSPACE), the Army's central organization providing operational space support.[176]

Fig. 3-37. Army Astronaut Lieutenant Colonel Nancy J. Currie aboard the space shuttle, maneuvering the remote arm.

The Army's renewed interest in space and space-related assets began with its participation in the TENCAP program and blossomed as it underwent a doctrinal renaissance and training revolution that resulted in AirLand Battle Doctrine. The demands of the new doctrine forced the Army's leadership to look toward the ultimate high ground to satisfy a commander's new critical information requirements. By mid-1985 the ASIS group was developing a report that would give the Army a vision for the potential of space. Mixed in with the vision were a series of practical recommendations to realize the vision. The study advocated a division of labor between the Army Staff, ARSPACE, ASI, AMC and UASSDC. The object was to give the Army the tools it would need to satisfy its current and future needs.

As the Army began debating the ways it should use space, it began developing doctrine and operational concepts and created a space command headquarters. It also grappled with the issue of creating a cadre of space-trained soldiers and began promoting Army space exploitation. However, this was only a beginning, as the Army still had to create a doctrine that would exploit space assets. That the ultimate end users of space-related information did not participate in forming their own requirements led to an imperfect acquisition strategy. Most important was the difficulty of getting the majority of the Army's senior leadership to wholeheartedly support operational space exploitation roles and missions.

As the Cold War abruptly ended, the Army was faced with a new strategic environment. The world grew smaller as the United States had fewer overseas bases. As the Army began to change from a forward deployed force to one that could project power, it would depend more on space capabilities for surveillance, warning, communications, navigation, meteorology and geodesy.

End Notes

[1]SAFSCOM General Orders 4, dated 12 February 1971 and SAFSCOM General Orders 7, dated 19 March 1971
[2]Quoted in Clarence A. Robinson, Jr., "Missile Engineering, Prototype Site Defense Construction Set," *Aviation Week & Space Technology*, 29 April 1974.
[3]System Charters SAFEGUARD Ballistic Missile Defense System dated 24 March 1971 and 7 May 1971.
[4]Each module consisted of three radars and 100 interceptors. By the early 1970s commercial software and data processing systems had developed to the extent that off-the-shelf technology could be incorporated into advanced systems at lower cost.
[5]Hardsite Defense was shortened to Site Defense in April 1972.
[6]Site Defense System Fact Book dated 1 December 1974.
[7]"Testimony of Secretary of Defense James R. Schlesinger to the Senate Committee on Armed Services Conducting Hearings on Military Procurement for FY76 and the 3-Month Transition Period" Ballistic Missile Defense Systems Command, Annual Historical Review FY76 and 7T, Volume II.
[8]Effective date was 28 October 1975.
[9]General Orders 12, dated 22 May 1974. Similarly, the SAFEGUARD System Manager, System Organization and the Systems Command were renamed the Ballistic Missile Defense (BMD) Program Manager, BMD Program Office and BMD Systems Command (BMDSCOM) respectively. The SAFEGUARD Systems Site Activation Command was assigned to BMDSCOM under General Orders 3 issued on 17 June 1974.
[10]The role of the ABMDA had been to develop advanced technologies to minimize deployment times. The BMDATC was a Class II activity with its own competitive area and line in the DOD budget.
[11]See BMDATC General Orders 4, dated 8 July 1975 and BMDATC General Orders 5, issued 15 October 1975
[12]In the Huntsville competitive area, which included small field offices in New York, New Jersey, North Carolina, Florida, California, and Montana, the authorized personnel strength reduced from 577 civilians and 46 military personnel to 345 civilians and 31 military personnel. The personnel strength had already been reduced in July 1973 to 58% of that allowed prior to the ABM treaty.
[13]BMD Overview Briefing Presented to Drs. Fletcher and Agnew on 21 July 1983.
[14]Secretary of Defense Schlesinger Testimony to the Senate Committee on Armed Services Conducting Hearings on Military Procurement for FY76 and the 3-Month Transition Period. Schlesinger continued stating that this "R&D … assists in the design and evaluation of our strategic offensive systems … [and] assists our intelligence agencies in the assessment of Soviet BMD capabilities."
[15]Secretary of Defense Harold Brown Annual Report to Congress dated 2 February 1978, quoted in Ballistic Missile Defense Organization, *Ballistic Missile Defense Organization Annual Historical Review Fiscal Year 1978, 1 October 1977 – 30 September 1978*.
[16]*Ibid*. p. vii.
[17]In recognition of these advances, in October 1977, Secretary of the Army Clifford Alexander authorized the first Army Award for Project Management outside the Department of Army Readiness Command, be awarded to Brigadier General John G. Jones for his outstanding accomplishments on the BMD program.
[18]United States Senate, Senate *Hearings on FY 77 Authorizations, Part 12, Research and Development*, pp. 6679, 6682-84, and 6686-87. Quoted in Baucom, *Origins*, pp. 98-99.
[19]Summary of BMDSCOM Activities FY76/7T, Unpublished typescript.
[20]Bulk filtering refers to the ability to quickly eliminate lightweight objects such as tank debris and traffic decoys from further consideration. Discrimination is the more precise ability to differentiate between precision decoys and RV's. New Technology, Inc., *History of Ballistic Missile Defense Developments: A Synopsis* (Huntsville: BMDATC, 1983), p. 31.
[21]See, for example, Historical Office, *Ballistic Missile Defense Systems Command Annual Historical Review, 1 October 1976—30 September 1977*, Volume I, pp. IV—13-14.
[22]The SAFEGUARD MSR was 50 times larger that the STR. Similarly the battle management data processor was 10 times larger than its proposed replacement which was also 50% more capable. Briefing to Drs. Fletcher and Agnew, 21 July 1983.

[23]Clarence A. Robinson, Jr., "Strategic Shifts – 3: Missile Defense Radar System Tests Set," *Aviation Week and Space Technology* 20 September 1976. The STR "featured separate waveforms for search, bulk filtering, tracking, discrimination, and interceptor tracking and guidance." McDonnell Douglas Astronautics Company, *Ballistic Missile Defense: A History of Achievement* (Huntington Beach, California: 1982).
[24]Frances Martin, et al., *Four Decades of Progress*, p. 53
[25]Bell Aerospace, "Optical Aircraft Measurement Program," http://www.ball.com/aerospace/oamp.html.
[26]Public Affairs Office, U.S. Army Strategic Defense Command, "Airborne Optical Adjunct (AOA) Project," 1985.
[27]As part of the modification to the Boeing 767, the aircraft was equipped with an 86-foot long and 10-foot high cupola to house the optical sensor.
[28]Ballistic Missile Defense Advanced Technical Center, Annual Historical Review FY75.
[29]Kenneth J. Stein, "New Missile Defense Systems Studied," *Aviation Week and Space Technology* 11 October 1976: 46-47.
[30]For a brief overview of the evolution of DE weapons see Baucom, *Origins*.
[31]Major General Donald L. Lamberson (USAF), "DoD's Directed Energy Program: Its Relevance To Strategic Defense," *Defense* June 1983: 16-20.
[32]Matthew Nichols, "Early Concepts for Space-Based Ballistic Missile Defense," unpublished paper presented at the Conference of Army Historians, August 2002.
[33]Clarence A. Robinson, Jr., "Amy Pushes New Weapons Effort," *Aviation Week and Space Technology* 16 October 1978.
[34]*Ibid*.
[35]Baucom, *Origins*, p. 109. Space was viewed as the optimum medium as particles in the atmosphere caused thermal blooming and scattering of the beam.
[36]Ballistic Missile Defense Organization, *Ballistic Missile Defense Organization Annual Historical Summary, FY81,* (Huntsville: BMDO, n.d.) p. 1.
[37]Historical Office*, Ballistic Missile Defense Systems Command Annual Historical Review, 1 October 1976—30 September 1977*, Volume I, pp. IV—118-119.
[38]The endoatmosphere is defined as the distance between the Earth's surface and 300,000 feet altitude.
[39]The small phased array radars were 1/40th the size of the site defense. The interceptor measured 15 feet, one half the size of a SPRINT missile. The missiles would be capable of accelerating to 8,500 feet in only 1.5 seconds and would reach an altitude of 4,000 to 5,000 feet in about one second. Baucom, *Origins*, p. 117 and Office of Technology Assessment, *MX Missile Basing* (Washington, D.C.: 1981). As defined in the Ballistic Missile Defense Organization FY84 Annual Historical Review, n.d. "a distributed data processing system is one in which there exists a multiplicity of interconnected processing resources able to cooperate under system-wide control on a single problem with minimal reliance on centralized procedures, data, or hardware."
[40]*MX Missile Basing*, p. 8. Each of the 200 missiles would be based in clusters of 23 shelters. Each cluster would contain one MX, 22 decoys, 23 shelters, one large transporter truck and one maintenance truck.
[41]BMD Program Office, "FY1982 Historical Input for BMP," undated, p. 2 cited in Walker, Martin, *Four Decades*, p. 45.
[42]The treaty for example would also have limited the number of LoAD batteries to 18, as each battery included a radar. See *MX Missile Basing*, p. 142.
[43]Ballistic Missile Defense Organization, *Ballistic Missile Defense Organization Annual Historical Review Fiscal Year 1979* (Huntsville: BMDO, n.d.).
[44]This type of kill vehicle contains no warhead and destroys its target by direct impact - kinetic energy.
[45]The HOE measured 70.6 feet and weighed a total of 68,081 pounds, 1200 kilograms attributed to the kill vehicle. The kill device, a radial net, has been likened to the folded skeleton of an umbrella with weights attached to its ribs.
[46]Baucom, *Origins*, p. 103.
[47]The first HOE flight occurred on 7 February 1983. The test achieved 85% of its goals. Some opponents accused the Army of employing homing beacons on the target and charges on the interceptor. The GAO refuted accusations that the HOE tests were rigged in their report "Ballistic Missile Defense: Records Indicate Deception Program Did Not Affect 1984 Results" published in July 1994.
[48]Lockheed Missiles and Space, "Homing Overlay Experiment,"
http://lmms.external.lmco.com/newsbureau/photos/hoe1_caption.html.

[49]Quoted in *U.S. Army First in Space and Strategic Defense*, USASDC Public Affairs Office pamphlet.
[50]Baucom, *Origins*, p. 103.
[51]The SRHIT successfully completed its first flight test to assess missile performance and stability on 20 January 1984. This was the first in a series of nine tests.
[52]At the request of the Army Staff the name change took place in January 1986.
[53]U.S. Army Strategic Defense Command, *U.S. Army Strategic Defense Command Annual Historical Review Fiscal Year 1987* (Huntsville, Alabama: USASDC, n.d.).
[54]The FLAGE measured 148.94 inches in length and 9 inches in diameter. The missile weighed 504.9 a total of pounds.
[55]Traveling at a rate of 3200 feet per seconds, the entire flight lasted 7 seconds. The tests took place at White Sands Missile Range.
[56]"Ballistic Missile Defense, The Army's Strategic Weapons Program," .n.d, p. 5. Clarence A. Robinson, "Soviets Grasping Strategic Lead," *Aviation Week & Space Technology* 30 Aug 1976: 14-18
[57]Trolone, "Ballistic Missile Threat," p. 6.
[58]Malcolm W. Browne, "Weapon that Fights Missiles Could Alter World Defense Focus" *New York Times* 4 December 1978: 1, 3.
[59]Report of the President's Commission on Strategic Forces, 6 April 1983, Brent Scowcroft Chairman, p. 18, quoted in Ruth Currie-McDaniel and Claus Martel, *The U.S. Army Strategic Defense Command, Its History and Role in the Strategic Defense Initiative*, 3rd edition (Huntsville, Alabama: USASDC, 1989), p. 25. The report stated "vulnerability of such silos in the near term … is not sufficiently dominant part of the overall problem of ICBM modernization to warrant … ABM defense of these silos."
[60]*Ibid*.
[61]*Ibid*., p. 18.
[62]Dennis M. Gormley, *Double Zero and Soviet Military Strategy: Implications for Western Security* (London: Jane's Publishing Company, 1988), pp.13-14.
[63]Until 1964, when China exploded its first nuclear weapon, there was only a Soviet strategic threat. This was a complication but not a threat because the Chinese had no missiles and few bombs. However, there was no way to gauge the speed of Chinese ICBM development and no way to determine how much saber rattling was genuine and how much was bombast. After the Sino-American rapprochement in 1972 this was a moot point. The post-Cold War period brought renewed concerns about Chinese military development.
[64]This point was made by John M. Collins, *U.S.-Soviet Military Balance, 1980-1985* (Washington, D.C.: Pergamon-Brassey's, 1985), p. 4.
[65]See the statement of President Reagan and the Pentagon related to the MX missile in "Text of Reagan and Pentagon Statements on MX Missile Proposal," *New York Times*, 23 November, 1982, A14.
[66]See Gormley, pp. 36-43, especially pp. 37-39.
[67]See Gormley, p. 40 and Stephen Kotkin, *Armageddon Averted: The Soviet Collapse, 1997-2000* (New York: Oxford University Press, 2001).
[68]The standard works include Robert A. Doughty, *The Evolution of U.S. Army Tactical Doctrine, 1946-1976* (Fort Leavenworth: Combat Studies Institute U.S. Army Command and General Staff College, 1979), Paul H. Herbert, *Deciding What Has To Be Done: General William E. DePuy and the 1976 Edition of FM 100-5 Operations* (Fort Leavenworth: Combat Studies Institute, U.S. Army Command and General Staff College, 1988), Jonathan M. House, *Combined Arms Warfare in the 20th Century* (Lawrence: University Press of Kansas, 2001) and John L. Romjue, *From Active Defense to AirLand Battle: The Development of Army Doctrine, 1973-1982* (Fort Monroe: Historical Office, U.S. Army Training and Doctrine Command, 1984). DePuy's own views may be found in Romie L. Brownlee and William J. Mullen III, *Changing An Army: An Oral History of General William E. DePuy, USA Retired* (Washington, D.C.: Government Printing Office, n.d.) and Richard M. Swain (comp.), *Selected Papers of General William E. DePuy: First Commander, United States Army Training and Doctrine Command,* edited by Donald L. Gilmore and Carolyn Conway (Fort Leavenworth: Combat Studies Institute, U.S. Army Command and General Staff College, 1994). The then Commandant of the U.S. Army Command and General Staff College expressed his point of view in John H. Cushman, *U.S. Army Operational Doctrine as Expressed in FM 100-5 and the Defense of Central Europe* (McLean: MITRE Corporation, 1978). Retrospective accounts include William E. DePuy, "FM 100-5 Revisited." *Army* 30 (November 1980):12-17, L. D. Holder, "Doctrinal Development, 1975-

1985," *Military Review* 65.5 (May 1985):50-52, Donn A. Starry, "A Tactical Evolution-FM 100-5," *Military Review* 58.8 (August 1978):2-11, Donn A. Starry, " A perspective on American Military Thought," *Military Review* 69.7 (1989): 2-11 and Huba Wass de Czege and L. D. Holder, "The New FM 100-5," *Military Review* 62.7 (July 1982):53-70. A recent account of the early stage is Richard Lock-Pullan, "'An Inward Looking Time': the United States Army, 1973-1976," *The Journal of Military History* 67 (April 2003): 483-512. For more general information on the subject of military innovation, see Colin Gray, *Weapons Don't Make War: Policy, Strategy and Military Technology* (Lawrence: University Press of Kansas, 1993), Stephen Peter Rosen, *Winning the Next War: Innovation and the Modern Military* (Ithaca: Cornell University Press, 1981), McGregor Knox and Williamson Murray (eds.), *The Dynamics of Military Revolution, 1300-2050* (New York: Cambridge University Press, 2001), Williamson Murray and Allan R. Millett (eds.), *Military Innovation in the Interwar Period* (New York: Cambridge University Press, 1996).

[69]This new thinking concentrated on developing new antiballistic missile technologies, including reduced-sized high speed integrated circuit computer processors, High Endoatmospheric Defense Interceptors (HEDI), the Ground-Based Laser and the Airborne Optical Adjunct. For greater detail see the section on missile defense.

[70][Linton Brooks], "CNO and the Strategic Defense Initiative," n.d., quoted in Baucom, *Origins*, p. 190.

[71]The name was coined by opponents who questioned a reliance on "exotic technology."

[72]Speech by President Ronald Reagan, "Peace and National Security, A New Defense," 23 March 1983.

[73]President Reagan issued the directive on 25 March 1985.

[74]Donald Baucom, "Missile Defense Milestones 1944-2000,"
http://www.acq.osd.mil/bmdo/bmdolink/html/milstone.html.

[75]Issued 6 January 1984.

[76]Effective 15 April 1984.

[77]William H. Taft IV, Deputy Secretary of Defense, issued a revision to Directive No. 5141.5 on 4 June 1987 which transferred supervision of the SDIO program to the Deputy Secretary of Defense.

[78]In addition to the Army, Air Force and Navy, other participants in the SDIO were the Defense Nuclear Agency and the Defense Advanced Research Project Agency. Teledyne Brown Engineering, "The Relevance of Previous Anti-Ballistic Missile Programs to the Strategic Defense Initiative," Special Report SS89-USASDC-3221, Contract # DASG60-87-C-0042, 28 March 1989, 9-5.

[79]General Orders 26, dated 24 October 1985. The effective date for this transition was 1 July 1985.

[80]Once again headed by lieutenant general, the USASDC was headquartered in Washington, D.C.

[81]The eight research areas of the Fletcher Report were consolidated into five program elements: surveillance, acquisition, tracking and kill assessment; DEW; KEW; survivability, lethality and key technologies; and systems concepts/battle management.

[82]Paul Warnke, a director of the Arms Control and Disarmament Agency in the Carter Administration observed that "S.D.I. is all things to all people. To the President, it is saving peoples' lives. To Defense Secretary Weinberger, it is a technological stepping stone from missile defense … To others, it was simply a means of defending missiles. To some, it was a bargaining chip in arms-control negotiations, while to others … it was untouchable." Quoted in Philip Boffey, et. al. *Claiming the Heavens The New York Times Complete Guide to the Star Wars Debate* (New York: Times Books, 1988), p. 65.

[83]Keith Payne, *Strategic Defense: "Star Wars" in Perspective*, Foreword by Zbigniew Brzezinski (Langham, MD: Hamilton Press, 1986).

[84]Lou Cannon, "Reagan's Big Idea. (Ronald Reagan's Strategic Defense Initiative)" *National Review* 22 February 1999, http://www.findarticles.com/cf_natrvw/m!282/199_Feb_22/53703734/print.jhtml and Boffey, et. al. *Claiming the Heavens*.

[85]Reprinted from Chapter 12, Walker, Martin and Watkins, *Four Decades of Progress*.

[86]Reprinted with additions from Chapter 13, Walker, Martin and Watkins, *Four Decades of Progress*.

[87]As designed the laser would be "several football fields long and situated on a 20-square mile site." Heike Hasenauer, "Army Takes the Lead in ASAT," *Soldiers,* August 1989. A FEL uses electrons that have been "freed" from atomic nuclei and are accelerated to near the speed of light in a particle accelerator and then "wiggled magnetically" to produce a beam. Unlike a regular laser beam, a FEL "can be 'tuned' to any wavelength, from microwave to the ultraviolet" with research continuing to explore means to extend the range up to other spectrums. Boffey, et. al., *Claiming the Heavens*, pp. 35.

[88]Besides boost phase intercept capabilities, the projected benefits of a GBL system were target imaging and kill assessment, an unlimited magazine and target discrimination. Briefing, "GBFEL Site Dedication, White Sands Missile Range, New Mexico, 2 July 1990.
[89]Colonel Nicholas Barrón, et. al., "U.S. Army Strategic Defense Command Ground-Based Laser Project Office A History and Lessons Learned, 1986 to 1991," 19 April 1991.
[90]By 1986, FEL systems had already demonstrated the most powerful laser to date operating at only 42% efficiency (converting electrical power into laser light). Boffey, et. al., *Claiming the Heavens*, pp. 35-36.
[91]Briefing, "GBFEL Site Dedication." The dedication ceremony took place in July 1990. The USASDC completed termination of the Ground-Based Laser Project Office on 1 August 1991.
[92]Directed Energy Weapons Fact Sheet, prepared by the USASDC Public Affairs Office, dated March 1992.
[93]Office of Technology Assessment, *Strategic Defenses*, p. 154.
[94]GAO Report "Ballistic Missile Defense Information on Directed Energy Programs for Fiscal Years 1985 Through 1993." GAO/NSIAD-93-182, dated June 1993. The objectives not yet achieved included: generation of a scalable high-power beam, development of electrical power source, test of integrated ground test accelerator on the ground and Test of NPB operation in space.
[95]Directed Energy Weapons Directorate, "Information Paper," dated March 1993.
[96]Reprinted with additions from Chapter 14 of Walker, Martin and Watkins, *Four Decades of Progress*.
[97]On 9 November 1985, Secretary of the Army John O. Marsh, Jr., signed the charter for the ERIS Project Office and appointed the Army's first civilian project manger, Mr. James Katechis.
[98]John Bosma and Richard Whelan, *Guide to the Strategic Defense Initiative* (Arlington, Virginia: Military Space, 1985), 257.
[99]Historical Office, *U.S. Army Strategic Defense Command – Annual Historical Review Fiscal year 1986* (Huntsville: USASDC, n.d.), II-151.
[100]The integrated system test vehicle and ERIS flight version measured 13 feet 2 inches from the nose tip of the kill vehicle to the end of the adapter section. During flight the ERIS would reach speeds of about 4 miles per second.
[101]"Strategic Defense test flight 'an unqualified success,'" *The Redstone Rocket*, 6 February 1991: 3.
[102]Ground-Based Interceptor Project Office Historical Report for Fiscal Year 1992.
[103]Reprinted with additions from Chapter 15 of Walker, Martin and Watkins, *Four Decades of Progress.*
[104]Historical Office, *U.S. Army Strategic Defense Command Annual Historical Review Fiscal Year 1987* (Huntsville: USASDC, 1990), 239.
[105]Boeing determined "a sensor with a 20-degree by 100-degree field of view with a detection range of about 100 miles could provide coverage of a 100,000 square mile defended area." Bosma and Whelan, *Guide*, 118. The aircraft carried 25 linked computers. The sensor system included 38,000 detectors.
[106]"Airborne surveillance testbed successfully tracks targets," *The Redstone Rocket*, 26 June 1992: 4.
[107]Reprinted with additions from Chapter 15 of Walker, Martin and Watkins, *Four Decades of Progress.*
[108]Historical Office, *AHR FY86*, II-144.
[109]Media Briefing presented by GBR Project Manager, Colonel Arthur C. Meier II, on 5 June 1989.
[110]Developed by Raytheon, the GBR-X would be a dual-field-of-view radar, able to see at both short and long distances, by incorporating both limited-field-of-view and full-field-of-view techniques. The radome measured 80 feet in diameter. The radar enclosure would be 43' W X 50'D X53'H and weigh 750,000 pounds.
[111]Vincent Kiernan, "Defense Panel Gives Green Light to SDI Ground-Based Radar," *Space News* (30 July –5 August 1990), 17.
[112]Reprinted with additions from Chapter 15 of Walker, Martin and Watkins, *Four Decades of Progress.*
[113]Currie-McDaniel and Martel, *Strategic Defense Command*, 70.
[114]"SDC awards contract to McDonnell Douglas," *The Redstone Rocket*, 5 October 1988: 2.
[115]Ground-Based Surveillance and Tracking System Project Office Historical Report for Fiscal Year 1993, dated 22 October 1993. A delayed deployment precluded the development of the GSTS as a precursor to the Brilliant Eyes sensor system.
[116]Reprinted with additions from Chapter 15 of Walker, Martin and Watkins, *Four Decades of Progress*.
[117]The rail launched HEDI would be the fastest interceptor traveling at Mach 15, about 10,000 mph. The kill vehicle weighed 800 pounds.… Hasenauer, "Army Takes the Lead."

[118]Mr. Alan Sherer, the second civilian to selected as Program Manager was named the HEDI PM later that year. On 29 April 1991, Mr. Sherer was the first civilian to be named Project Manager of the Year.
[119]Historical Office, *U.S. Army Strategic Defense Command Annual Historical Review, Fiscal Year 1989*, unpublished. The USASDC awarded the HEDI contract to McDonnell Douglas in January 1986.
[120]The shroud protects the sensor and its sapphire crystal window during the early part of flight. The window is cooled with liquid nitrogen after the shroud is removed. Marsha Taylor, "SDC conducts successful kinetic kill vehicle test," *The Redstone Rocket*, 31 January 1990: 5.
[121]HEDI Historical Report for Fiscal Year 1990, dated 19 November 1990.
[122]"U.S. Army's HEDI Concept Evolves Into More Capable Two-Stage Interceptor," *Aviation Week & Space Technology* 7 January 1991: 62.
[123]No intercepts were attempted during these HEDI tests. HEDI Historical Report for Fiscal Year 1992, dated 23 November 1992.
[124]Press Release, "Termination of Contract for High Endoatmospheric Defense Interceptor," 16 September 1992.
[125]Boffey, et.al., *Claiming the Heavens*, pp. 198-200.
[126]Marshal Grechko quoted in Reagan's 13 July 1985 "Radio Address to the Nation on the Strategic Defense Initiative," http://www.reagan.utexas.edu/resource/speeches/1985/71385a.htm. The speech adds that the Soviets have continued to pursue missile defense research for the last 20 years, to deploy an ABM system around Moscow, and have begun to construct new facilities, such as the Krasnoyarsk radar, which violate the treaty.
[127]Boffey, et.al., *Claiming the Heavens*, pp. 198-200.
[128]Joseph Cirincione, "A Brief History of Ballistic Missile Defense," Speech presented at a conference in Como, Italy, 2-4 July 1998, adapted from *The Persistence of the Missile Defense Illusion*, http://www.ceip.org/Programs/npp/bmdhistoyr.htm. Mr. Cirincione was a Senior Associate with the Carnegie Endowment for International Peace.
[129]Donald Baucom, "The U.S. Missile Defense Program, 1944-1994: Fifty Years of Progress," dated 14 November 1994. Brilliant Pebbles were described as "stand-along, 'un-garaged' interceptors" weighing 10-25 kilograms equipped with on-board sensors and computers.
[130]Reprinted from Chapter 16 of Walker, Martin and Watkins, *Four Decades of Progress*.
[131]Equipped with a state of the art imaging infrared seeker, high-density lightweight electronics, low-drift fiber optic IMU, and a compact high energy liquid or solid-divert propulsion system the LEAP kill vehicle weighed 15 pounds.
[132]Public Affairs Office Fact Sheet, "Lightweight Exoatmospheric Projectile (LEAP)," April 1992; Vincent Kiernan, "SDI: Setbacks Expected – Critics Blast Program After Last Month's LEAP Failure," *Space News*, 13 July 1992, 3 and 29; and "Third LEAP test misses intercept," *BMD Monitor*, 2 July 1993; Robert Holzer, "Navy Panel May Speed Missile Tests," *Defense News*, 31 July – 6 August 1995, 38.
[133]Missile Defense Agency Fact Sheet, "Sea Based Midcourse Defense," dated 2002.
[134]Reprinted with additions from Chapter 16, Walker, Martin and Watkins, *Four Decades of Progress*.
[135]Headed by Brigadier General J. Morgan Jellett, the Kinetic Energy Anti-Satellite Joint Program Office was established on 27 February 1989. "DAB Selects Ground-Based Mode for Initial KEW ASAT," *Defense Daily*, 15 December 1989, 405. The Army also has previous experience with ASAT technology. During the NIKE-ZEUS era, the command was directed to develop an ASAT capability using the ZEUS missile system. This ability was validated in 1962.
[136]Historical Office, *U.S. Army Strategic Defense Annual Historical Review Fiscal Year 1989*, unpublished.
[137]Vincent Kiernan, "Lengthy Delay Hits Laser ASAT Work," *Space News*, 20 August 1990: 1.
[138]James Asker, "Rockwell Selected as Sole Contractor for $100-Million ASAT Design Effort," *Aviation Week and Space Technology*, 23 July 1990.
[139]Anti-Satellite Joint Program Office Historical Report for Fiscal Year 1991, dated 5 December 1991.
[140]Anti-Satellite Joint Program Office Historical Report for Fiscal Year 1992, dated 27 January 1993.
[141]Gerda Sherrill, "SSDC strapdown test a success," *The Redstone Rocket*, 21 September 1994, 6.
[142]USASSDC News Release, "KE ASAT hover test is highly successful," 12 August 1997. Equipped with an on-board seeker, processor, and guidance equipment, the 94-pound device unfolds "a sail-like device … shortly before impact to strike and disable the target" and minimize space debris.
[143]Reprinted with additions from Chapter 18 of Walker, Martin, and Watkins, *Four Decades of Progress*.
[144]Briefing, "U.S. Army Strategic Defense Command High energy Laser Systems Test Facility," dated

5 December 1991.

[145]General Orders 12, dated 8 May 1991. This transfer "is consistent with OSD desire to consolidate strategic test facilities and weapons development under one command."

[146]HELSTF Historical Report for Fiscal Year 1991, dated 5 December 1991.

[147]Combined Arms Center History Office, *U.S. Army Combined Arms Center Annual Historical Review 1988* (Fort Leavenworth, 1989), pp. 270-275.

[148]The following, unless otherwise noted, is based on Chapter Two (Army Space History) of the Army Space Reference Text.

[149]"Message: Army Management Structure for Space, 19 November 1984."

[150]Provisionally, the new agency would "represent Army interests in developing space-related strategic defense planning." It would also "investigate and report to appropriate Army organizations on space-related technology research and development programs of other services and DoD activities which may apply to the mission requirements of Army forces." See "Message regarding the provisional Activation of the U.S. Army Space Agency, 28 July 1986."

[151]"Message: Army Element of USSPACECOM, 18 October 1985."

[152]It was aided by the Intelligence and Security Command, the RAND Corporation Arroyo Center and the TRADOC Assistant Chief of Staff for Intelligence.

[153]TRADOC Military History Office, *Annual Historical Review 1986* (Fort Monroe: TRADOC Military Office, 1987), p. 80 (secret—information used is unclassified).

[154]TRADOC Military History Office, *Annual Historical Review 1986* (Fort Monroe: TRADOC Military Office, 1987), p. 81 (secret—information used is unclassified). See also *Mitchell, Apogee, Perigee and Recovery*, pp. 45-48.

[155]Combined Arms Center History Office, *U.S. Army Combined Arms Center Annual Historical Review 1991* (Fort Leavenworth, 1992), p. 331 and Combined Arms Center History Office, *U.S. Army Combined Arms Center Annual Historical Review 1994* (Fort Leavenworth, 1996), "Chapter 7: Combat Developments."

[156]"Briefing, U.S. Army Space Institute, January 1989, Mission" (chart 2.).

[157]Steven Siegel, "Army Space Institute," *Army Trainer* Summer 1987:20-21.

[158]Marquis Shepherd, "Army Unit to Bring Technology of Space Down to Earth for Troops," *Kansas City Times*, 13 January 1988:B-3.

[159]Combined Arms Center History Office, *U.S. Army Combined Arms Center Annual Historical Review 1987* (Fort Leavenworth, 1988), pp. 145, 160, 161, 221-226

[160]Between December 1986 and March 1987, the Deputy Chief of Staff for Research, Development and Acquisition (DCSRDA) received demonstration submissions from organizations across the Army. From these, the DCSRDA selected five and presented them to the Army Space Council in April 1987, at the same meeting the ASI presented the proposed Army Space Concept. The VCSA ordered ASI to review the space demonstration program to ensure the proposed demonstrations melded to the proposed concept. In June, the Institute presented a final list for the proposed Army Space Demonstration Program, which was approved in August 1987.

[161]For a very brief treatment, see Donald W. Evans, *U.S. Army Use of Space-Based Systems,* www.globalsecurity.org/space/library/report/1990/EDW.htm, accessed on 4 February 2003.

[162]Combined Arms Center History Office, *U.S. Army Combined Arms Center Annual Historical Review 1986* (Fort Leavenworth, 1987), pp. 88-93

[163]Combined Arms Center History Office, *U.S. Army Combined Arms Center Annual Historical Review 1987* (Fort Leavenworth, 1988), p. 226. At this time, the Army was not seeking the same kind of expertise it had developed earlier. Now, the emphasis was on applied knowledge, ways in which the new tools serve as a force enabler and enhancer.

[164]In 1958, at NASA's request, the four armed services submitted the names of 508 pilots, including 35 Army officers who had graduated from test pilot school. In January 1959, NASA concluded that only 110 of them met the minimum standards of age, height, education, physical condition and jet pilot flying time. None were Army personnel. Eventually, NASA pared the 110 down to the seven Mercury astronauts after a series of written tests, interviews and physical and psychological examinations. Army pilots generally failed to qualify because they flew only helicopters and rotary engine aircraft rather than jets. See William E. Burrows, *This New Ocean: The Story of the Space Age* (New York: Random House, 1998), pp. 288-289.

[165]While many of these "scientist-astronauts" successfully completed the NASA training program, only one, Harrison H. Schmidt, ever flew on an Apollo mission. Edward G. Gibson, Owen K. Garriot and Joseph P. Kerwin flew on various Skylab crews. Not until the shuttle program of the early 1980s did most of the scientists, now called mission specialists, fly on actual missions.
[166]See Chapter 5 of David Compton, *Where No Man Has Gone Before: A History of Apollo Lunar Exploration Missions* (Washington, D.C.: National Aeronautics and Space Administration, Office of Management, Scientific and Technical Information Division, 1989) (NASA Special Publication-4214, NASA History Series, 1989).
[167]Major Thomas C. Winter, Jr., "The Army's Role in Space," *Military Review*, 48.7 (July 1968):82-86.
[168] General William C. Westmoreland to Dr. Robert C. Gilruth, 10 February 1969, Johnson Space Center Collection, 071-11.
[169]Dr. Robert C. Gilruth to General William C. Westmoreland, 25 February 1969, Johnson Space Center Collection, 071-11.
[170]Burrows, *This New Ocean*, pp. 518-523.
[171]Joseph D. Atkinson and Jay M. Shafritz, *The Real Stuff: A History of NASA's Astronaut Recruitment Policy* (New York: Praeger, 1985), pp. 131-171.
[172]Memorandum of Understanding between the Department of Defense, the Army, the Navy and the Air Force and the National Aeronautics and Space Administration Concerning the Detailing of Military Personnel for Service as Shuttle Crew members, 17 December 1976.
[173]Heike Hasenauer, "The Army Astronaut Program," *Soldiers* 45.2 (February 1990):18.
[174]See the ninth chapter, "Military Man in Space," in U.S. Army Space Reference Text, http://www-tradoc.army.mil/dcscd/spaceweb/internet2.htm, accessed 3 March 2003. Material in the following paragraphs is based on this source.
[175]Memorandum of Understanding between the National Aeronautics and Space Administration and the Department of the Army, 17 May 1987.
[176]ARSPACE traces its roots to the Army Staff Field Element established to act as liaison to the U.S. Air Force Space Command and initiate planning for Army participation in the unified U.S. Space Command (USSPACECOM) in 1984. In 1985, this staff field element became the Army Space Planning Group, the Army component of USSPACECOM. In 1986, the planning group was designated the Army Space Agency (ASA), a Field Operating Agency of the DCSOPS. In 1988, the ASA became ARSPACE and in August 1992, ARSPACE became a subordinate command of the U.S. Army Space and Strategic Defense Command, a predecessor of the U.S. Army Space and Missile Defense Command. An overview of the events leading up to creating ARSPACE may be found in Lieutenant Colonel Patrick Gagan, "The Army Space Command," *Military Review* 58.3 (March 1988):44-51.